

Peer Review of the Plan for the Assessment of Detection and Quantitation Limits  
Under Section 304(h) of the Clean Water Act

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**APPENDIX C**

**Reviewer A Curriculum Vitae**

Reviewer A  
*Curriculum Vitae*  
January 2002

<Affiliation, Addresses, Telephone Numbers and E-mail Addresses Removed>

**PERSONAL**

Birth date: June 4, 1946  
Married, two children  
U.S. Citizen

**EDUCATION**

Ph.D., University of Illinois, Chicago, 1972 (Mathematics)  
Supplemental Coursework, University of Chicago, 1977–79 (Statistics)  
M.A., University of Illinois, Chicago, 1968 (Mathematics)  
A.B., Shimer College, 1966 (Mathematics and Physics)

**HONORS**

National Merit Scholarship, 1964–66.  
Graduated "With Distinction" from Shimer College, 1966.  
National Science Foundation Graduate Fellowship, 1968–71.  
Fellow of the Royal Statistical Society, 1979.  
Youden Prize, Chemical Division, American Society for Quality Control, 1982.  
Award for Interlaboratory Testing, American Statistical Association, 1985.  
Shewell Award, Chemical and Process Industries Division, American Society for Quality Control, 1987.  
Fellow of the American Statistical Association, 1995.  
Statistics in Chemistry Award, American Statistical Association, 1997.  
Elected to Membership in the International Statistical Institute, 1997.  
Distinguished Service Award, Division of Molecular Orthopaedics, University of Pennsylvania, 2000.

**EMPLOYMENT**

Professor, <Affiliation Removed>, Davis, 2000–present, Vice-Chair, 2001–present.  
Professor, <Affiliation Removed>, 1997–present; Acting Director of Biostatistics 1997–2000.  
Co-Director, <Affiliation Removed>, 1996–present.  
Director, <Affiliation Removed>, 2001–present.  
Professor Graduate School of Management, UC Davis, 1986–2000. Associate Professor, 1980–1986.  
Director, Center for Statistics in Science and Technology, UC Davis, 1995–99.  
Academic Visitor, Department of Mathematics, Imperial College, London, 1987–1988.  
University Professor of Business Administration, Governors State University, 1974–80.  
Lecturer (visiting), Department of Mathematics, University of Illinois, Chicago, 1972–74.  
Scientific Computer Programmer, Argonne National Laboratory, Summers 1965–69.

## **COURSES TAUGHT**

Introductory Statistics  
Regression Analysis and Linear Models  
Experimental Design  
Time Series Analysis and Forecasting  
Bootstrap Methods  
Mathematical Physics  
Management Science  
Production and Operations Management  
Program Evaluation  
Quality and Productivity Improvement  
Technology Management  
Introduction to Computing  
Computer Architecture/Assembly Language  
Other Mathematics courses

## **RECENT GRANTS AND CONTRACTS**

Air Force Office of Scientific Research, 2001–03, Center for Digital Security, PI with two Co-PI's.  
University of California Life Sciences Informatics Program and Surromed Inc., 2000–2002, Prediction, Classification, and Analysis of Highly Multivariate Biomedical Laboratory Data, (with <Co-author>).  
National Science Foundation, 1998–02, Robust Multivariate Analysis and Outlier Identification in Massive Data Sets (with <Co-author>).  
National Institutes of Health, National Institute of Environmental Health Sciences, 1988–2005, Statistical analysis of toxics measurement data.  
National Science Foundation, 1997–02, PI for UC Davis component of the National Partnership for Advanced Computing Infrastructure (Supercomputer) project centered at UCSD, 3 Co-PI's at UC Davis.  
US Environmental Protection Agency, 1997–02, Statistical Methods and Computer Implementation for Precision Determination for Low Level Analytes.  
National Aeronautics and Space Administration, 1998–01, Towards Real-Time Vector Field Visualization for Massive and Multi-Source Data using Hierarchies, Co-PI, Bernd Hamann PI.  
Lawrence Livermore National Laboratory, 1998–01, Hierarchical Methods for the Representation and Visualization of Terascale Data Coupled with Data Mining and Immersive Environments. Co-PI, Bernd Hamann PI.  
National Institutes of Health, National Cancer Institute, 1997–01, BPH: Molecular Biology of P53 and BCL-2 Alterations, Statistician, Paul Gumerlock PI.  
National Institutes of Health, National Cancer Institute, 1998–01, Protein Interaction with the N-terminus of the Androgen Receptor, Statistician, Paul Gumerlock PI.  
National Institutes of Health, National Cancer Institute, 1998–01, Functions of Different P53 Mutations in Prostate Cancer, Statistician.  
National Science Foundation, 1998–99, Applications of Parallel Computing in Computer Science, Computer Engineering, and Analysis and Visualization of Massive Data Sets (CISE Equipment Grant). PI with two Co-PI's.  
National Science Foundation, 1995–99, Center for Statistics in Science and Technology, Group Infrastructure Grant. Project director with 5 Co-PI's and 6 Faculty Associates.

## MEMBERSHIP IN PROFESSIONAL SOCIETIES

American Association for the Advancement of Science  
American Mathematical Society  
American Society for Quality Control  
American Statistical Association (Fellow)  
Association for Computing Machinery  
Bernoulli Society  
Biometric Society  
Institute of Mathematical Statistics  
International Association for Statistical Computing  
International Society for Computational Biology (Treasurer 2002, Board of Directors 2002–2004)  
International Statistical Institute  
Mathematical Association of America  
Royal Statistical Society (Fellow)  
Society for Industrial and Applied Mathematics

## EDITORIAL WORK

Associate Editor, *Journal of Business and Economic Statistics*, 1986–1995  
Associate Editor, *Biometrics*, 1997–2000  
Associate Editor, *Metrika*, 1998–  
Reviewer for: *American Journal of Political Science*, *Annals of Statistics*, *Applied Statistics*, *Australian Journal of Statistics*, *Bioinformatics*, *Biometrics*, *Biometrika*, *BIT*, *Canadian Journal of Statistics*, *Communications in Statistics*, *Computational Statistics and Data Analysis*, *International Studies Quarterly*, *Irwin, John Wiley*, *Journal of Applied Statistical Science*, *Journal of Computational Biology*, *Journal of Conflict Resolution*, *Journal of Immunological Methods*, *Journal of Forecasting*, *Journal of Multivariate Analysis*, *Journal of Nonparametric Statistics*, *Journal of Quality Technology*, *Journal of Statistical Computation and Simulation*, *Journal of Statistical Planning and Inference*, *Journal of the American Statistical Association*, *Journal of the Royal Statistical Society B*, *National Science Foundation*, *Naval Research Logistics*, *SIAM Journal on Scientific and Statistical Computing*, *The Statistician*, *Technometrics*, *University of Michigan Press*, *West*, *World Politics*.

## BOOKS

- 1995 <Co-author> and Reviewer A, *Optimal Imperfection? Domestic Uncertainty and Institutions in International Relations*, Princeton: Princeton University Press.  
1990 <Co-author> and Reviewer A, *Tacit Bargaining, Arms Races, and Arms Control*, Ann Arbor: University of Michigan Press.

## STATISTICAL THEORY AND METHODOLOGY

- 2002 <Co-author> and Reviewer A, "Classification in High Dimension with Application to DNA Microarray Data," submitted for publication.  
2002 Reviewer A and <Co-author>, "Multivariate Outlier Detection and Cluster Identification," submitted for publication.  
2002 <Co-author> and Reviewer A, "Robust Distances," submitted for publication.  
2002 Reviewer A and <Co-author>, "Sampling and Subsampling for Cluster Analysis in Data Mining, with Applications to Sky Survey Data," submitted for publication.  
2002 <Co-author> and Reviewer A "Multivariate Survival Analysis with Doubly Censored Data: Application to the Assessment of Accutane Treatment for Fibrodysplasia Ossificans Progressiva," *Statistics in Medicine*, in press

- 2001 Reviewer A and <Co-author> "Discussion of Multivariate Outlier Detection and Robust Covariance Matrix Estimation," *Technometrics*, **43**, 300–303.
- 2001 <Co-author> and Reviewer A "Analyte Identification in Multivariate Calibration," *Biometrics*, **57**, 571–576.
- 1999 <Co-author's Name Removed, <Co-author>, Reviewer A, and <Co-author>, "Some Computational Issues in Cluster Analysis with No A Priori Metric," *Computational Statistics and Data Analysis*, **31**, 1–12.
- 1999 <Co-author> and Reviewer A "Bootstrapping in Controlled Calibration Experiments," *Technometrics*, **41**, 224–233.
- 1998 Reviewer A, "Constructive Statistics: Estimators, Algorithms, and Asymptotics," *Computing Science and Statistics*, **30**, 3–14.
- 1998 Reviewer A, "A Perspective on Statistical Tools for Data Mining Applications," *Proceedings of the Second International Conference on Practical Application of Knowledge Discovery and Data Mining*, 313–318.
- 1998 Reviewer A, "Laboratory Quality Control," in *Encyclopedia of Biostatistics*, New York: John Wiley.
- 1997 Reviewer A and <Co-author>, "Optimal Design for ELISA and other forms of Immunoassay," *Technometrics*, **39**, 162–170.
- 1997 Reviewer A and <Co-author>, "Robust Estimation of Multivariate Location and Shape," *Journal of Statistical Planning and Inference*, **57**, 245–255.
- 1996 Reviewer A and <Co-author>, "Identification of Outliers in Multivariate Data," *Journal of the American Statistical Association*, **91**, 1047–1061.
- 1996 Reviewer A, "Robustness Properties of S-Estimators of Multivariate Location and Shape in High Dimension," *Annals of Statistics*, **24**, 1327–1345.
- 1995 Reviewer A and <Co-author> "Prediction of Automotive Emissions from Gasoline Composition," *Proceedings of the 1994 Spring Research Conference on Statistics in Industry and Technology*, American Statistical Association.
- 1995 Reviewer A and <Co-author>, "A Two-Component Model for Measurement Error in Analytical Chemistry," *Technometrics*, **37**, 176–184.
- 1994 Reviewer A and <Co-author>, "Multivariate Outlier Detection," in *Proceedings of the 26th Symposium on the Interface: Computing Science and Statistics*, 392–400.
- 1994 <Co-author> and Reviewer A, "Computable Robust Estimation of Multivariate Location and Shape using Compound Estimators," *Journal of the American Statistical Association*, **89**, 888–896.
- 1993 <Co-author> and Reviewer A, "Heuristic Search Algorithms for the Minimum Volume Ellipsoid," *Journal of Computational and Graphical Statistics*, **2**, 69–95.
- 1993 Reviewer A, "Almost-Exact Parametric Bootstrap Calculation via the Saddle-Point Approximation," *Computational Statistics and Data Analysis*, **15**, 451–460.
- 1993 Reviewer A and <Co-author>, "Computation of Robust Estimates of Multivariate Location and Shape," *Statistica Neerlandica*, **47**, 27–42.
- 1993 Reviewer A, "On the Beta Transformation Family," *Technometrics*, **35**, 72–81.
- 1992 Reviewer A and <Co-author>, "Computation of High-Breakdown Estimates of Multivariate Location and Shape," *Proceedings of the ASA Statistical Computing Section*, 34–39.
- 1992 Reviewer A, " $\bar{X}_Q$  and  $R_Q$  Charts: Robust Control Charts," *The Statistician*, **41**, 97–104.
- 1992 Reviewer A, "Estimation of Variation after Outlier Rejection," *Computational Statistics and Data Analysis*, **13**, 9–20.
- 1991 Reviewer A, "Robustness and Balance in the Mixed Model," *Biometrics*, **47**, 303–309.
- 1990 Reviewer A, "The Adjusted p-Chart and u-Chart for Varying Sample Sizes," *Journal of Quality Technology*, **22**, 206–209.

- 1990 <Co-author> and Reviewer A, "On the Cumulants of Affine Equivariant Estimators in Elliptical Families," *Journal of Multivariate Analysis*, **35**, 203–222.
- 1989 Reviewer A, "Robust Control Charts," *Technometrics*, **31**, 173–184.
- 1989 Reviewer A, "Bootstrap Bartlett Adjustment for Seemingly Unrelated Regression," *Journal of the American Statistical Association*, **84**, 598–601.
- 1987 <Co-author>, Reviewer A, and <Co-author>, "Standard Errors for Elasticities: A Comparison of Bootstrap and Asymptotic Standard Errors," *Journal of Business and Economic Statistics*, **5**, 145–149.
- 1986 Reviewer A and <Co-author>, "The Scale Problem in Robust Regression M-Estimates," *Journal of Statistical Computation and Simulation*, 1986, **24**, 47–69.
- 1986 Reviewer A, "Outlier Resistance in Small Samples," *Biometrika*, **73**, 175–181.
- 1986 <Co-author> and Reviewer A, "Numerical Methods for Robust Regression: Linear Models," *SIAM Journal on Scientific and Statistical Computing*, **7**, 86–97.
- 1984 Reviewer A, "On Testing for Bioequivalence," *Biometrics*, **40**, 225–230.
- 1983 <Co-author> and Reviewer A, "Municipal Budget Forecasting with Multivariate ARMA Models," *Journal of Forecasting*, **2**, 377–387.
- 1983 <Co-author> and Reviewer A, "Designed Experiments for Classification Problems," *Journal of the Operational Research Society*, **34**, 1069–1077.
- 1983 <Co-author> and Reviewer A, "Multivariate ARIMA Models and Municipal Finance," in *Applied Time Series Analysis of Economic Data*, ed. Arnold Zellner, Bureau of the Census.
- 1983 Reviewer A, "Robust Statistical Analysis of Interlaboratory Studies," *Biometrika*, **70**, 421–431.
- 1982 Reviewer A, "Inference for Response-Limited Time Series Models," *Communications in Statistics*, **A11**, 2587–2596.
- 1982 Reviewer A, <Co-author> and <Co-author> "Are Robust Estimators Really Necessary?" *Technometrics*, **24**, 95–102.
- 1981 Reviewer A and <Co-author>, "Estimating the Variance of Estimators of Location: Influence, Curve, Jackknife and Bootstrap," *Communications in Statistics*, **B10**, 221–248.
- 1980 Reviewer A and <Co-author>, "Time Series with Episodic Disruptions" in *Analysing Time Series*, ed. O.D. Anderson, New York: North-Holland.
- 1975 Reviewer A, "p-Groups with Abelian Centralizers," *Proceedings of the London Mathematical Society*, **3**, **30**, 55–75.

#### **MEDICINE, BIOLOGY, CHEMISTRY, ENVIRONMENTAL SCIENCE**

- 2002 Reviewer A, <Co-author>, <Co-author>, and <Co-author>, "Modeling Uncertainty in Analytical Measurements for Analysis of Bioavailability," submitted for publication.
- 2002 <Co-author>, <Co-author>, <Co-author>, and Reviewer A, "Analytical Methodologies for Metal Speciation," submitted for publication.
- 2002 <Co-author> and Reviewer A, "Multi-Class Cancer Classification via Partial Least Squares with Gene Expression Profiles," submitted for publication.
- 2002 <Co-author> and Reviewer A, "Partial Least Squares Proportional Hazard Regression for Application to DNA Microarray Data," submitted for publication.
- 2002 <Co-author>, Reviewer A, <Co-author>, and <Co-author>, "Application to Environmental Monitoring of a Two-Component Model for Chemical Analytical Error," submitted for publication.
- 2002 <Co-author> and Reviewer A, "Classification of Acute Leukemia Based on DNA Microarray Gene Expressions Using Partial Least Squares," in *Methods of Microarray Data Analysis*, S. M. Lin and K. F. Johnson, eds., Kluwer, in press.

- 2002 <Co-author> and Reviewer A, "Tumor Classification by Partial Least Squares using Gene Expression Data," *Bioinformatics*, in press.
- 2001 Reviewer A and <Co-author>, "A Model for Measurement Errors for Gene Expression Arrays," *Journal of Computational Biology*, **8**, 557–569.
- 2000 <Co-author> and Reviewer A, "A GIS-Based Approach to Spatial Allocation of Area Source Solvent Emissions," *Environmental Modelling and Software*, **15**, 293–302.
- 2000 <Co-author> and Reviewer A, "Modeling Spatial Variation in Area Source Emissions—A Poisson Regression Approach," *Journal of Agricultural, Biological and Environmental Statistics*, **5**, 7–21.
- 2000 <Co-author>, <Co-author>, <Co-author>, Reviewer A, and <Co-author>, "Smoking as a Risk Factor for Accident Death: A Meta-analysis of Cohort Studies," *Accident Analysis and Prevention*, **32**, 397–405.
- 1999 <Co-author>, <Co-author>, <Co-author>, and Reviewer A, "Smoking as a Risk Factor for Injury Death: A Meta-analysis of Cohort Studies," *Preventive Medicine*, **27**, 871–878.
- 1998 <Co-author>, <Co-author>, <Co-author>, Reviewer A, <Co-author>, and Sean S. Duffey, "Dietary Protein and Chlorogenic Acid Effect on Baculoviral Disease of Noctuid (Lepidoptera: Noctuidae) Larvae," *Environmental Entomology*, **27**, 1264–1272.
- 1998 <Co-author>, <Co-author>, <Co-author>, Reviewer A, <Co-author>, and <Co-author>, "Effects of Plant Identity and Chemical Constituents on the Efficacy of a Baculovirus Against *Heliothis Virescens*," *Journal of Chemical Ecology*, **24**, 221–252.
- 1998 <Co-author>, <Co-author>, <Co-author>, <Co-author>, <Co-author>, <Co-author>, <Co-author>, Reviewer A, <Co-author>, and <Co-author>, "Urinary Basic Fibroblast Growth Factor: A Biochemical Marker for Preosseous Fibroproliferative Lesions in Patients Who Have Fibrodysplasia Ossificans Progressiva," *Clinical Orthopaedics and Related Research*, **346**, 59–65.
- 1998 <Co-author>, Reviewer A, and <Co-author>, "Catastrophic Falls in Patients Who Have Fibrodysplasia Ossificans Progressiva," *Clinical Orthopaedics and Related Research*, **346**, 110–116.
- 1998 <Co-author>, Reviewer A, <Co-author>, <Co-author>, and <Co-author>, "Tréatment of Patients Who Have Fibrodysplasia Ossificans Progressiva with 13-cis-Retinoic Acid (Isotretinoin)," *Clinical Orthopaedics and Related Research*, **346**, 121–129.
- 1998 <Co-author>, <Co-author>, <Co-author>, and Reviewer A., "Mechanism for Superior Subluxation of the Glenohumeral Joint in Patients Who Have Fibrodysplasia Ossificans Progressiva," *Clinical Orthopaedics and Related Research*, **346**, 130–133.
- 1997 <Co-author>, <Co-author>, Reviewer A, and <Co-author>, "Immunoassay of Cross-Reacting Analytes," in *Immunochemical Technology for Environmental Applications*, D. S. Aga and E. M. Thurman, eds., ACS Symposium Series No. 657, 331–342, Washington, D.C.: American Chemical Society Publications.
- 1996 <Co-author>, <Co-author>, <Co-author>, and Reviewer A, "A Procedure for the Immunoanalysis of Samples Containing One or More Members of a Group of Cross-Reacting Analytes," *Analytica Chimica Acta*, **336**, 175–183.
- 1996 <Co-author>, <Co-author>, <Co-author>, <Co-author>, and Reviewer A, "On the Application of the Bootstrap to Calibration Experiments," *Analytical Chemistry*, **68**, 763–770.
- 1996 <Co-author>, <Co-author>, <Co-author>, Reviewer A, and <Co-author>, "An Approach to the Construction of an Immunoarray for Differentiating and Quantitating Cross Reacting Analytes," *Analytica Chimica Acta*, **319**, 291–303.
- 1996 <Co-author>, <Co-author>, <Co-author>, Reviewer A, <Co-author>, <Co-author>, and <Co-author>, "Severe Restriction in Jaw Movement Following Routine Injection of Local Anesthetic in Patients who have Fibrodysplasia Ossificans Progressiva," *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontics*, **81**, 21–25.

- 1995 <Co-author>, <Co-author>, <Co-author>, <Co-author>, and Reviewer A, "Sources of Experimental Variation in Calibration Curves for Enzyme-Linked Immunosorbent Assay," *Analytica Chimica Acta*, **313**, 197–207.
- 1995 Reviewer A, "Optimal Design of Quantitative Immunoassay Protocols," in *New Frontiers in Agrochemical Immunoassay*, David Kurtz, ed., Washington, DC: Association of Official Analytical Chemists, 251–259.
- 1995 <Co-author>, <Co-author>, Reviewer A, <Co-author>, and <Co-author>, "Permanent Heterotopic Ossification at the Injection Site Following Routine Diphtheria-Tetanus-Pertussis Immunizations in Children who have Fibrodysplasia Ossificans Progressiva," *Journal of Pediatrics*, **126**, 762–764.
- 1995 <Co-author>, <Co-author>, <Co-author>, Reviewer A, and <Co-author>, "An Immunoarray for the Simultaneous Determination of Multiple Triazine Herbicides," *Analytica Chimica Acta*, **304**, 339–352.
- 1995 <Co-author>, <Co-author>, <Co-author>, <Co-author>, <Co-author>, <Co-author>, <Co-author>, <Co-author>, and Reviewer A, "Predicting Ligand Binding to Proteins by Affinity Fingerprinting," *Chemistry and Biology*, **2**, 107–118.
- 1994 <Co-author>, <Co-author>, <Co-author>, <Co-author>, <Co-author>, <Co-author>, and Reviewer A, "Extension of the Four-Parameter Logistic Model for ELISA to Multianalyte Analysis," *Journal of Immunological Methods*, **177**, 1–7.
- 1994 Reviewer A, <Co-author>, <Co-author>, <Co-author>, and <Co-author>, "Age- and Joint-Specific Risk of Initial Heterotopic Ossification in Patients who have Fibrodysplasia Ossificans Progressiva," *Clinical Orthopaedics and Related Research*, **301**, 243–248.
- 1990 <Co-author>, Reviewer A, and <Co-author>, "Statistical Design of ELISA Protocols," *Journal of Immunological Methods*, **132**, 247–254.

#### POLITICAL SCIENCE

- 1998 <Co-author>, Reviewer A, and <Co-author>, "Managing the Evolution of Multilateralism," *International Organization*, **52**, 397–419.
- 1996 <Co-author>, Reviewer A, and <Co-author>, "Is the Good News about Compliance Good News for Cooperation?" *International Organization*, **50**, 379–406, reprinted in *International Institutions* Lisa A Martin and Beth A Simmons, eds., 2001, Cambridge:MIT Press.
- 1994 <Co-author> and Reviewer A, "Conflict, Agency, and Gambling for Resurrection: The Principal-Agent Problem Goes to War" *American Journal of Political Science*, **38**, 362–80.
- 1986 <Co-author> and Reviewer A, "Tacit Bargaining and Arms Control," (1987) *World Politics*, **39**, 297–325.
- 1985 <Co-author>, Reviewer A, and <Co-author>, "Arms Races and Cooperation," *World Politics*, **38**, 118–146, reprinted in *Cooperation under Anarchy*, Princeton University Press.
- 1984 <Co-author> and Reviewer A, "Theories of Budgetary Decisionmaking and Revenue Decline," *Policy Sciences*, **16**, 329–347.
- 1982 <Co-author> and Reviewer A, "Ceteris Paribus Revisited," *Political Methodology*, 43–54.
- 1980 <Co-author> and Reviewer A, "Complexity, Interaction and Policy Research," *Policy Sciences*, **13**, 281–295.
- 1980 <Co-author> and Reviewer A, "Bureaucracy and Juvenile Corrections," in *Determinants of Public Policy*, Thomas Dye and Virginia Gray, eds., Lexington MA: Heath-Lexington.
- 1979 <Co-author> and Reviewer A, "Interpreting Heteroscedasticity," *American Journal of Political Science*, **23**, 816–828.



## PATENTS

- 2001 <Co-author> and Reviewer A, "Algorithm for Clustering Genes based on Microarray Data," (pending).
- 2000 Reviewer A and <Co-author>, "A Method for Determining Measurement Error for Nucleic Acid Microarrays," 60/233,547 (pending)
- 2000 Reviewer A and <Co-author>, "Analysis of Gene Expression from DNA Microarrays using Partial Least Squares," 60/233,546 (pending)

## BOOK REVIEWS

- Genetic Algorithms + Data Structures = Evolution Programs (3<sup>rd</sup> Edition)*, by Zbigniew Michalewicz, *Journal of the American Statistical Association*, 2000, **95**, 347–348.
- Directions in Robust Statistics and Diagnostics, Parts I and II*, edited by Werner Stahel and Sanford Weisberg, *Journal of the American Statistical Association*, 1993, **88**, 710–711.
- Robust Estimation and Testing*, by Robert G. Staudte and Simon J. Sheather, *International Statistical Institute Short Book Reviews*, 1991, **11**, 6.
- Mixture Models: Inference and Application to Clustering*, by G. J. McLachlan and K. E. Basford, *International Statistical Institute Short Book Reviews*, 1988, **8**, 26.
- Analysis of Experiments with Missing Data*, by Yadolah Dodge, *Technometrics*, 1987, **29**, 116.
- Robust Inference*, by M. L. Tiku, W. Y. Tan, N. Balakrishnan, *Technometrics*, 1987, **29**, 495–496.

## INVITED PRESENTATIONS

- 2001 Reviewer A, "Statistical Analysis of Gene Expression Data," Invited Presentation, Chiron, Emeryville, CA, November.
- 2001 Reviewer A, "Modeling Uncertainty in Analytical Measurements for Analysis of Bioavailability," *Methodologies for Assessing Exposure to Metals: Speciation, Bioaccessibility and Bioavailability in the Environment, Food and Feed*, Scientific Group on Methodology for the Safety and Evaluation of Chemicals (SGOMSEC), Schmallenberg, Germany, October.
- 2001 Reviewer A, "Statistical Analysis of Gene Expression Data," Invited Presentation, The Scripps Research Institute, San Diego.
- 2001 Reviewer A and <Co-author>, "Variance Functions, Transformations, and the Integrity of Statistical Inference with Biological Data," Invited Presentation, SurroMed, Inc., August.
- 2001 Reviewer A, "Robust Multivariate Analysis and Outlier Detection," Invited Presentation, *Society for Industrial and Applied Mathematics Annual Meeting*, San Diego, July.
- 2001 Reviewer A, "Statistical Analysis of Gene Expression Data," Invited Presentation, University of California, San Diego, June.
- 2001 Reviewer A, "Statistical Analysis of Gene Expression Data," Invited Presentation, Michigan State University, May.
- 2001 Reviewer A, "Statistical Analysis of Gene Expression Microarray Data," Invited Presentation, Merck, March.
- 2001 Reviewer A, "Statistical Analysis of Gene Expression Microarray Data," Invited Presentation, University of Washington, February.
- 2001 Reviewer A, "Statistical Analysis of Gene Expression Microarray Data," Invited Presentation, Lawrence Livermore National Laboratory, February.
- 2000 Reviewer A, "Statistical Analysis of Gene Expression Microarray Data," Invited Presentation, *EUCHEM Conference on Bioinformatics, Cheminformatics, Datamining, and Chemometrics*, Swedish Chemical Society, Stockholm, September.

- 2000 Reviewer A and <Co-author>, "Robust Clustering," Invited Presentation, *Controlling Complexity for Strong Stochastic Dependencies*, Mathematisches Forschungsinstitut Oberwolfach, Oberwolfach, Germany, September.
- 2000 Reviewer A, <Co-author>, and <Co-author>, "Robust Cluster Analysis and Outlier Identification," Invited Presentation, *Joint Statistics Meetings 2000*, Indianapolis, August.
- 1999 Reviewer A, "Robust Multivariate Analysis and Outlier Detection," Invited Presentation, Mathsoft, Inc., Seattle, November.
- 1999 Reviewer A and <Co-author>, "Bootstrapping in Controlled Calibration Experiments," Invited Presentation, *43<sup>rd</sup> Annual Fall Technical Conference*, American Society for Quality, American Statistical Association, Houston, October.
- 1999 Reviewer A, "Data Mining," Invited Presentation, *Gordon Research Conference on Statistics in Chemistry and Chemical Engineering*, Plymouth, MA, July.
- 1999 Reviewer A, "Robust Cluster Analysis and Outlier Identification," Invited Presentation, *Conference on Complexity Reduction in Multivariate Datasets*, Universität Dortmund, March.
- 1998 Reviewer A, "Clustering and Outlier Detection in Massive, High-Dimensional Data Sets," Invited Presentation, *NIPS 98 Workshop on Mining Massive Databases: Scaling Prediction and Clustering to Massive and High Dimensional Data*, Breckenridge, CO, December.
- 1998 Reviewer A, "Interdisciplinary Collaboration: Why and How?" Invited Presentation, *Society for Industrial and Applied Mathematics Meeting*, Chicago, October.
- 1998 Reviewer A, "Constructive Statistics: Estimators, Algorithms, and Asymptotics," Invited Presentation, University of Illinois, Chicago, September.
- 1998 Reviewer A, "Constructive Statistics: Estimators, Algorithms, and Asymptotics," Invited Presentation, Pfizer Central Research, Groton, CT, August.
- 1998 Reviewer A, "A Two-Component Model for Measurement Error in Analytical Chemistry," Invited Presentation, National Institute for Standards and Technology, Gaithersburg, MD, July.
- 1998 Reviewer A, "A Two-Component Model for Measurement Error in Analytical Chemistry," Invited Presentation, United States Environmental Protection Agency, Washington, DC, July.
- 1998 Reviewer A, "Constructive Statistics: Estimators, Algorithms, and Asymptotics," Invited Keynote Address, *30th Symposium on the Interface: Computing Science and Statistics*, Minneapolis, MN, May.
- 1997 Reviewer A, "Robust Multivariate Analysis and Outlier Detection," Invited Plenary Address, *Annual Meeting of the Belgian Statistical Society*, Mol, Belgium, October.
- 1997 Reviewer A and <Co-author>, "Partitioning and Subsampling to Uncover Subtle Structure in Massive Data Sets," Invited Presentation, *Summer Research Institute on Data Mining*, Seattle, Washington, June.
- 1997 Reviewer A, "Statistics of Measurement Error in Analytical Chemistry," Invited Presentation, *EPA Twelfth Annual Conference on Environmental Statistics*, Richmond, VA, April.
- 1997 Reviewer A, "Partitioning and Subsampling to Uncover Subtle Structure in Massive Data Sets," Invited Presentation, *Approaches to the Analysis and Visualization of Massive Data Sets Workshop*, San Diego, CA, March 14 and 15.
- 1996 Reviewer A, "Statistical Methods for the Identification of and Measurement of Mixtures of Similar Toxic Substances," Invited Presentation, *Superfund Basic Research Program: A Decade of Improving Health through Multidisciplinary Research*, Chapel Hill, NC, February.

- 1996 Reviewer A, "A Two-Component Model for Measurement Error in Analytical Chemistry," Invited Presentation, *ASMS Fall Workshop on Limits to Confirmation, Quantitation, and Detection*, Alexandria, VA, November.
- 1996 Reviewer A and <Co-author>, "Robust, Affine-Equivariant Cluster Analysis," Invited Presentation, DuPont, Wilmington, DE, October.
- 1996 <Co-author>, Reviewer A, and <Co-author>, "Design and Evolution of Multilateral Agreements," Invited Presentation, *American Political Science Association Annual Meeting*, September.
- 1996 Reviewer A and <Co-author>, "The Problem of Preference Change in International Security Agreements," Invited Presentation, *American Statistical Association Annual Meeting*, Chicago, August.
- 1996 <Co-author>, Reviewer A, and <Co-author>, "Regime Design and the Depth of Cooperation," Invited Presentation, *International Studies Association Annual Meeting*, San Diego, CA, April.
- 1996 Reviewer A, "Robust Scale-Free Cluster Analysis," Invited Presentation, Mathematisches Forschungsinstitut Oberwolfach, Mathematische Stochastik, Oberwolfach, Germany, March.
- 1996 Reviewer A and <Co-author>, "Identification of Outliers in Multivariate Data", Invited Presentation, DuPont, Wilmington, DE, February.
- 1995 Reviewer A, "Predictive Models for Reformulated Gasoline," Invited Presentation, Lawrence Livermore National Laboratory, Livermore, CA, August.
- 1995 Reviewer A and <Co-author>, "Heuristic Combinatorial Search Algorithms for the Detection of Outliers in High Dimension," Invited Presentation, Universität Hannover, Hannover, Germany, March.
- 1995 Reviewer A and <Co-author>, "Robust Estimation and the Identification of Outliers in Multivariate Data," Invited Presentation, Universität Dortmund, Dortmund, Germany, March.
- 1994 Reviewer A and <Co-author>, "Identification of Outliers in Multivariate Data," Invited Presentation, Merrill Lynch, Princeton, NJ, September.
- 1994 Reviewer A and <Co-author>, "Identification of Outliers in Multivariate Data," Invited Presentation, Columbia University, New York, NY, September.
- 1994 Reviewer A and <Co-author>, "Robust Estimation and the Identification of Outliers and Leverage Points in Multivariate Data," Invited Presentation, *Symposium on Future Directions in Robust Methods and Data Analysis*, Princeton, NJ, June.
- 1994 Reviewer A and <Co-author>, "Identification of Outliers in Multivariate Data," Invited Presentation, *26th Symposium on the Interface: Computing Science and Statistics*, Research Triangle Park, NC, June.
- 1993 <Co-author> and Reviewer A, "Strategies for Treaty Maintenance," Invited Presentation, *MIT/Harvard Joint Seminar Series on International Relations*, April.
- 1992 Reviewer A, "Optimal Design for Calibration Problems in ELISA," Invited Presentation, *Mathematical Sciences Research Institute Symposium on Industrial Statistics*, Berkeley, May.
- 1992 Reviewer A, "Statistical Design of Immunoassay Protocols," Invited Presentation, *American Chemical Society Annual Meeting*, San Francisco, April.
- 1989 Reviewer A, "Robust Control Charts," Invited Presentation, Temple University, Philadelphia, PA, October.
- 1986 Reviewer A, "Measuring Variation for Quality Improvement Applications," Invited Paper, *Annual Fall Technical Conference*, American Society for Quality Control, Charlotte, North Carolina.
- 1986 Reviewer A, "Measuring Variations for Quality Control Applications," Invited Paper, *International Research Conference on Reliability and Quality*, Columbia, Missouri.

- 1985 Reviewer A, "Robust Statistical Analysis of Interlaboratory Studies," Invited Paper, 1985 *Gorden Research Conference on Statistics in Chemistry and Chemical Engineering*.
- 1984 Reviewer A, "A Comparison of Robust and Standard Analyses of Interlaboratory Studies," Invited Paper, *Biometric Society ENAR meeting*, Orlando, Florida.
- 1982 <Co-author> and Reviewer A, "Multivariate ARIMA Modeling and Municipal Finance," Invited Paper, *Conference on Applied Time Series Analysis of Economics Data*, sponsored by the American Statistical Association, U.S. Bureau of the Census and the National Bureau of Economic Research.
- 1979 Reviewer A and <Co-author>, "Time Series with Episodic Disruptions," Invited Paper, *Second International Time Series Meetings*, October, Guernsey, U.K.

**APPENDIX D**

**Reviewer C Curriculum Vitae**

Reviewer C Ph.D.

Department of Applied and Engineering Statistics  
and The Center for Computational Statistics  
The School of Information Technology and Engineering

Address and Affiliation Removed

EDUCATION

1987 Ph.D. in Statistics, Stanford University  
1985 M.S. in Statistics, Stanford University  
1983 B.S. in Applied Mathematics, University of Virginia

RESEARCH INTERESTS

*General Areas:* Applied and Theoretical Statistics, Probability Theory

*Specialized Areas:* Computer Intensive Methods for Applied Statistics, Robust and Nonparametric Statistical Inference, Classification and Regression Trees, Random Packing and Geometric Probability

EMPLOYMENT HISTORY

1993- Associate Professor, Department of Applied and Engineering Statistics,  
Affiliation Removed  
1992-93 Assistant Professor, Department of Applied and Engineering Statistics,  
Affiliation Removed  
1987-92 Assistant Professor, Department of Operations Research and Applied Statistics,  
Affiliation Removed

EXPERIENCE

*University Teaching:* I have taught and designed both graduate level and undergraduate courses in statistics and probability. At the graduate level, I have taught the following courses: Statistical Inference, Applied Statistics, Nonparametric Statistics, Exploratory Data Analysis, Real Analysis and Statistics, Measure Theory and Linear Spaces I, and Advanced Topics in Statistics (several versions). I serve on numerous theses committees for both Ph.D. and Master's students (and I have been the thesis director in two cases), and I often assist faculty and graduate students throughout the university with the statistical aspects of their research. I serve as the Graduate Program Coordinator for the Department of Applied and Engineering Statistics.

*Consulting:*

1995-98 Provided statistical consulting services on regression analysis and classification analysis for Synergy, Inc.

1992-00 Provided statistical consulting services for American Research Company. Served as an advisor on a regression project on CEO compensation.

1985-96 Provided statistical consulting services and assisted in the preparation of statistical evidence for numerous legal cases, testifying as an expert witness in some of the cases.

1995 Provided statistical consulting services for Booz, Allen, and Hamilton. Performed times series analysis on a project for the FBI.

1995 Provided statistical consulting services for ViGYAN, Inc.

1995 Provided statistical consulting and training for the Saudi Arabian Monetary Agency.

1992 Provided statistical consulting services for The Rumson Corporation. Developed a new technique for the analysis of magnitude scaling data.

1992 Provided statistical consulting services for the United States Department of Education. Reviewed the Pell Grant evaluation procedure.

1992 Provided statistical consulting services for Knolls Atomic Power Laboratory. Consulted on time series analysis.

1989 Provided statistical consulting services for Kay Jewelers. Investigated and critiqued credit scoring procedures.

1987 Provided statistical consulting services for Opportunities Unlimited of Fairfax, Virginia. Performed computations for survey sampling project.

#### PUBLICATIONS

- [1] and Reviewer C (1986) A simulation study of random caps on a sphere. *J. Applied Probability* 23, 951-960.
- [2] Reviewer C (1989) Asymptotic packing densities for two-dimensional lattice models. *Commun. Statist. — Stochastic Models* 5, 601-615.
- [3] Reviewer C (1989) Packing densities of randomly constructed codes. *J. Applied Probability* 26, 512-523.
- [4] Reviewer C (1991) Improving classification trees with simulated annealing. *Proceedings of the 23rd Symposium on the Interface of Computing Science and Statistics*, E. M. Keramidas (Ed.), 395-402.
- [5] Reviewer C (1991) Using simulated annealing to sharpen tree structured classifiers. *Computational Statistics and Data Analysis* (accepted subject to revision).
- [6] and Reviewer C (1992) Forecasting the extent of the HIV/AIDS epidemic. *Socio-Economic Planning Sciences* 26, 149-168.
- [7] and Reviewer C (1992) How seriously is the U. S. AIDS population understated? *J. Washington Academy of Science*, 82, 79-109.
- [8] Reviewer C (1993) Computer-intensive methods for tests about the mean of an asymmetrical distribution. *J. American Statistical Association* 88, 802-810.
- [9] and Reviewer C (1993) The effect of oral irrigation with a magnetic water treatment device on plaque and calculus. *J. Clinical Periodontology*.
- [10] and Reviewer C (1993) Testing for Equality of Two Distribution Means in the Presence of Nonnormality and Heteroscedasticity. *Proceedings of the 25th Symposium on the Interface of Computing Science and Statistics*, M. Tarter (Ed.).
- [11] Reviewer C (1994) Tree structured density estimation. *Proceedings of the 26th Symposium on the Interface of Computing Science and Statistics*, J. Sall and A. Lehman (Eds.), 167-171.
- [12] Reviewer C (1998) Sphere Packing, *Encyclopedia of Statistical Sciences, Update*, Vol. 2, S. Kotz, C. Read, and D. Banks (Eds.), 628-632.
- [13] Reviewer C (1999) A comparison of regression methods. *Proceedings of the 31st Symposium on the Interface of Computing Science and Statistics*, K. Berk and M. Pourahmadi (Eds.), 482-486.

#### PRESENTATION/PARTICIPATION

1987-98 I gave seminars at the following institutions: Naval Postgraduate School, Southern Methodist University, Stanford University, SUNY Binghamton, University of Arkansas, University of Florida, and George Mason University.

2000 I presented my paper A comparison of quantile estimators and some tests about the median at the 2000 meeting of the Virginia Academy of Sciences held in Radford, VA.

1999 I presented my paper A comparison of regression methods at the 31st Symposium on the Interface of Computing Science and Statistics in Schaumburg, IL.

1998 I presented my paper On inference procedures for robust regression at the 1998 meeting of the Virginia Academy of Sciences held in Fairfax, VA.

1994 I presented my paper Tree structured density estimation at the 26th Symposium on the Interface of Computing Science and Statistics in Research Triangle Park, NC.

1993 My paper (coauthored by K. Buchanan) Testing for equality of two distribution means in the presence of nonnormality and heteroscedasticity was presented at the 25th Symposium on the Interface of Computing Science and Statistics in San Diego, CA.

1991 I presented my paper Improving classification trees with simulated annealing at the 23rd Symposium on the Interface of Computing Science and Statistics in Seattle, Washington.

1989 I presented my paper Asymptotic packing densities for two-dimensional lattice models at the ORSA/TIMS conference in New York City.

1989 Joint Statistical Meetings in Washington D. C. .

1988 I presented my paper *Packing densities of randomly constructed codes* at the 1988 Joint Statistical Meetings in New Orleans, LA.

1988 I chaired a session at the 20th Symposium on the Interface of Computing Science and Statistics in Fairfax, Virginia.

#### RESEARCH GRANTS and AWARDS

1997 Graduate Research Assistant awarded for 1997-1998 academic year (school-wide competition based on research proposals)

1994 Graduate Research Assistant awarded for 1994-1995 academic year (school-wide competition based on research proposals)

1990-1992 co-investigator on National Science Foundation Grant DMS9002237 (*Computational Statistical Methods for High Dimensional Statistical Inference*)

1990 Graduate Research Assistant awarded for 1990-1991 academic year (university-wide competition based on research proposals)

#### UNIVERSITY SERVICE

1998- Faculty Senate

1993-1998 Graduate Program Coordinator for Statistics Programs

1996-1998 CSI Admissions Committee

1995-1998 CSI Curriculum Committee

1993-1998 SITE Graduate Studies Committee

1988-1995 SITE Undergraduate Studies Committee

1995 Chairman of Search Committee for AES faculty opening

1994-1995 Faculty Senate Library Committee (Chairman in 1995-1996)

1992-1994 Faculty Senate Athletic Council

1988-1990 Seminar Committee (Department ORAS)

#### PROFESSIONAL SERVICE

1997- Associate Editor, *Comp. Statist. and Data Anal.*

1991-1996 Associate Editor, *Computational Statistics*

1988-1993 I have served as a reviewer for:

*J. Amer. Statist. Assoc.* (many times)

*Comp. Statist. and Data Anal.* (three times)

*Commun. Statist. — Stochastic Models*

*Canadian J. Statist.*

*Ann. Inst. Statist. Math.*

*Socio-Economic Planning Sciences*

The National Science Foundation

The John von Neumann National Supercomputer Center

Springer-Verlag

#### PROFESSIONAL AFFILIATIONS

Institute of Mathematical Statistics

International Association for Statistical Computing

American Statistical Association

Washington Statistical Society

Virginia Academy of Science



**APPENDIX E**

**Reviewer E Curriculum Vitae**

## Reviewer E, Technical Group Manager

<Affiliations and E-mail Address Removed>

### EDUCATION

B.S. General Science, Oregon State University	1967
M.S. Oceanography, University of Washington	1970
Ph.D. Oceanography, University of Washington	1974

### EXPERIENCE

Reviewer E is the Technical Group Manager for <Affiliation Removed>. He manages a staff of 18 involved in chemistry projects. Reviewer E has over 25 years experience in freshwater and marine geochemistry with emphasis on the concentration, speciation, and fate of trace elements in marine ecosystems. He has been the project manager of research contracts that required collecting and analyzing water, sediment and organisms, and seawater samples for butyltins, trace metals, and organic compounds, including seven years of analyses of NOAA Mussel Watch bivalve and sediment samples.

Reviewer E is internationally recognized in the field of marine pollution and trace metal analysis. He is frequently an invited participant or session chairman for workshops or scientific meetings that deal with arsenic speciation, marine monitoring, and the fate of contaminants in coastal waters. He has authored or coauthored nearly 100 journal articles and nearly 75 technical reports that apply geochemistry to diverse environmental issues.

- **Acid Volatile Sulfides (AVS).** Reviewer E has developed field sampling and analytical methods for the analysis of acid volatile sulfides (AVS) and simultaneously extracted metals (SEM) in marine and freshwater sediments. These methods have been used on the U.S. EPA Great Lakes Project and on NOAA's 1991 sediment survey of Long Island Sound.
- **Monitoring Offshore Platforms.** Reviewer E has been studying the distribution of contaminants on the continental shelf near oil and gas platforms for eight years with the CAMP II study in California and the Beaufort Sea Monitoring Program. Temporal trends in the concentrations of contaminants in age-dated sediment cores have also been investigated.
- **Atmospheric Deposition and Sea Surface Microlayer Chemistry.** Reviewer E made measurements of the deposition rate of airborne contaminants to a water surface and the fate of aerosols in seawater. He has collaborated in the sampling and analysis of sea surface microlayer and the relationship between chemistry and toxicity of the microlayer.
- **Analytical Chemistry.** Reviewer E is competent in the use of a variety of analytical techniques including atomic absorption spectrometry, neutron activation analysis, X-ray fluorescence, and inductively coupled plasma mass spectrometry. He has developed methods for the analysis of the speciation of mercury and arsenic in environmental samples. He has had considerable experience in field sampling techniques and strategies.
- **Fate and Effects of Contaminants in Coastal Waters.** Reviewer E has conducted research determining the chemical forms of arsenic in organisms and man, the form of mercury emitted by geothermal and coal fired power plants, and the forms and fate of copper and silver in the marine ecosystem. His current research projects involve investigation of the input rates of toxic trace metals

to the coastal marine environment and the biogeochemical and physical processes that control the distribution of these contaminants.

Reviewer E is a member of the American Chemical Society, the Oceanographic Society, and the Air and Waste Management Association. He received the Pan American Petroleum Fellowship during 1968-1969.

## INVITED PARTICIPATION

State of Washington Department of Ecology Arsenic Technical Scoping Committee, August 1999.

NOAA National Oceanographic Data Center Coastal Ocean Data Working Group Member, March 1997-1998

Developed Method 1632, *Chemical Speciation of Arsenic in Water and Tissue by Hydride Generation Quartz Furnace Atomic Absorption Spectrometry, Revision A*, for U.S. Environmental Protection Agency Office of Water, 1998.

Outer Continental Shelf Advisory Board, Scientific Committee, U.S. Department of the Interior, Minerals Management Service, 1996 to present.

Organizing committee member for six International Silver Conferences, Madison, Wisconsin, 1993-1999.

Session co-chairman for "clean metal" methods at SETAC Conference, Denver, Colorado, October 30 through November 3, 1994

Session leader for the Workshop on Organic Chemicals in the Great Lakes, Madison, Wisconsin, September 14-16, 1994.

Organizing committee member for the Second International Silver Conference, Madison, Wisconsin, September 11-14, 1994.

Participated in forum on the Environmental State of the Georgia Basin-Puget Sound-Juan de Fuca Region, Vancouver, British Columbia, January 13-14, 1994.

Assisted the Coast Guard and NOAA Hazmat with designing future investigations of the sunken vessel "Empire Knight"

Trace Metals Expert in a workshop for the development of trace metals methods for EPA's Analytical Methods Staff, November 12 and 13, 1993, Boston, Massachusetts.

Co-Chairman, "First International Conference on Transport, Fate and Effects of Silver in the Environment," August 8-10, 1993.

Chairman of Electric Power Research Institute Arsenic Health Studies Review, March 19-20, 1991, Palo Alto, California.

Member of the Puget Sound Water Quality Authority Research Committee, 1990 to present.

Member of the EPA Puget Sound Estuarine Program Technical Advisory Committee, 1987 to 1991.

**Reviewer E (Continued)**

Reviewer of EPA's "Toxicological Profile for Arsenic," 1991.

Thesis advisory committee member for two master students (University of Washington and Western Washington University).

Member of the Puget Sound Water Quality Authority Atmospheric Deposition Technical Work Team (1989-1991).

Adjunct Professor, Western Washington University, 1990 to present.

Expert witness for trials involving leaching of arsenic and heavy metals from mixtures of slag and wood waste, sedimentation rates and sediment chemistry in the east waterway of Everett, Washington, water quality near the city of Sequim outfall, and city of Lynnwood, Washington, secondary treatment waiver.

Speaker on Chemical Process for the Puget Sound Water Quality Authority Workshop on "A Briefing on Puget Sound Sediments," 1989, Tacoma, Washington.

Speaker for the Salén Discussions on Environmental Consequences of the Chemical Industry for the Atmosphere and the Oceans at the 32nd IUPAC Congress, August 2-7, 1989, Stockholm, Sweden.

Speaker at NCASI's West Coast Regional Meeting on "Temporal Trends of Contamination Recorded in Sediments of Puget Sound," 1989, Portland, Oregon.

Session Chairman for the Puget Sound Water Quality Authority Puget Sound Research Conference, March 8-13, 1988, Seattle, Washington.

Session Chairman for Chemistry at the Oregon Sediment Quality Workshop sponsored by Portland COE and Oregon Department of Environmental Quality, August 1988, Lincoln, Oregon.

Chair of the Chemical Working Session of the Bering Sea Monitoring Workshop, Minerals Management Service of the U.S. Department of Interior, January 14-15, 1987, Anchorage, Alaska.

Advisory Committee Member for the University of Washington Ruston/Vashon Island Environmental Pathway Study, March 23, 1984.

Rapporteur for U.S. Environmental Protection Agency Sediment Criteria Development Workshop, November 28-30, 1984, Alexandria, Virginia.

The Status and Trends Program: Recommendations for Design and Implementation of the Chemical Measurements Segment. NOAA Status and Trends Program Workshop, October, 1983.

Participant in the Second Workshop on Pollutant Transfer by Particulates, sponsored by NOAA/OMPA, April 27-29, 1983, Stony Brook, New York.

Reviewer for the Annual Program Review sponsored by the National Oceanic and Atmospheric Administration/Pacific Marine Environmental Laboratory, February 2-3, 1982, Seattle, Washington.

**Reviewer E (Continued)**

Participant in the Workshop on Pollutant Transfer by Particulates, sponsored by NOAA/OMPA, January 19-21, 1982, Norfolk, Virginia.

Participant in the Workshop on Sublethal Biological Effects of Pollutants in Marine Organisms sponsored by the California Department of Fish and Game and the Department of Energy, March 30-31, 1982, Asilomar, California.

Rapporteur for Intercalibration Exercises at the NATO Advanced Research Institute Symposium on "Trace Metals in Sea Water," Erice, March 30 -April 3, 1981, Sicily, Italy.

Participant in DOE Workshop on Environmental Effects of Photovoltaic Energy Technology, Brookhaven, New York, June 17-20, 1980.

Participant in DOE Workshop on "Processes Determining the Input Behavior and Fate of Radionuclides and Trace Elements in Continental Shelf Environments," Washington, D.C., March 7-9, 1979.

Speaker for the Geochemical Oceanography Seminar, University of Washington, Seattle, Washington, October 26, 1979.

Participant in NOAA Workshop Proceedings on Trace Metals and Marine Production Processes, Seattle, Washington, February 28-March 3, 1978.

Speaker for the First Symposium on Environmental Analytical Chemistry, Provo, Utah, June 21-23, 1978.

Participant in Workshop on Trace Metals sponsored by the U.S. Department of Commerce, Estes Park, Colorado, July 10-14, 1978.

Participant in EPRI Workshop on Fly Ash and Its Leachates, Palo Alto, California, May 24-26, 1978.

Discussion Leader - Session on Copper/Ecosystems Interactions. "Copper in the Marine Environment." Workshop adjunct to AGU Annual Meeting, December 7-8, 1977, San Francisco, California.

Rapporteur for Chemical Oceanography at the Bureau of Land Management Workshop on Recommendation for Baseline Research in Washington and Oregon, Relative to Offshore Resource Development, Portland, Oregon, December 15-17, 1976. U.S. Dept. of Energy Publication CONF-771236.

Participant on Panel 3. "Sediment Interaction." Workshop on the ERDA Marine Sciences Research Program for the West Coast of the United States." (W. L. Templeton, ed.), sponsored by DBER, Energy Research and Development Administration, March 17-19, 1976, Asilomar, California.

Participant in Workshop on Development and Characterization of Marine Standard Reference Materials (SRM) for Chemical Speciation Determinations. Sponsored by National Bureau of Standards, Catalina Island, October 8-10, 1975.

Reviewer E (Continued)

PUBLICATIONS

Journal Articles

<Co-author>, <Co-author>, and Reviewer E, "Inhibition of marine nitrification by ocean disposal of carbon dioxide", *Marine Pollution Bulletin*, accepted for publication, 2001.

<Co-author>, <Co-author>, <Co-author>, <Co-author>, Reviewer E, and <Co-author>. 2001. "Quantitative Relationship between Arsenic Exposure and AP-1 Activity in Mouse Urinary Bladder Epithelium." *Toxicological Sciences* 60 (2001):279-284.

<Co-author>, <Co-author>, Reviewer E, <Co-author>, <Co-author>, and <Co-author>. 1999. "A Market Basket Survey of Inorganic Arsenic in Food." *Food and Chemical Toxicology* 37(1999):839-846.

<Co-author>, and Reviewer E. 2000. "Inhibition of Marine Nitrification by Ocean Disposal of Carbon Dioxide." PNNL-SA-33944. *Environmental Science and Technology*.

<Co-author>, <Co-author>, Reviewer E, <Co-author>, and <Co-author>. 1999 "Elevated arsenic concentrations in bivalves from the southeast coasts of the USA." *Marine Environmental Research* 48(4-5):311-333. PNNL-. Pacific Northwest National Laboratory, Richland, WA.

<Co-author>, Reviewer E, and <Co-author>. 1997. [Refinement of the Borohydride Reductive Precipitation Preconcentration Technique for ICP-MS Analysis of Trace Metals in Sea Water.] *Analytica Chimica Acta* (submitted).

Reviewer E and <Co-author>. 1997. Intercomparison of Analytical Methods for Arsenic Speciation in Human Urine. *Environmental Health Perspectives* (accepted for publication).

<Co-author>, <Co-author>, <Co-author>, <Co-author>, <Co-author>, <Co-author>, Reviewer E, and <Co-author>. 1997. [Heavy Metal, Organochlorine Pesticide and Polychlorinated Biphenyl Contamination in Arctic Ground Squirrels (*Spermophilus parryi*) in Northern Alaska. *Arctic* 50(4)323-333.

<Co-author>, <Co-author>, <Co-author>, <Co-author>, <Co-author>, Reviewer E, and <Co-author>. "Environmental Assessment of Sea Surface Contamination in the Gulf." *Marine Pollution Bulletin* (submitted)

<Co-author>, <Co-author>, Reviewer E, and <Co-author>. "Quantification of Waterborne Mercury, Lead, Selenium and Arsenic in Freshwater and Marine Environments." *Environmental Science and Technology* (submitted)

<Co-author>, <Co-author>, <Co-author>, <Co-author>, <Co-author>, <Co-author>, <Co-author>, and Reviewer E. 1994. "Recalculation of the Oral Arsenic Toxicity Values Correcting for dietary Intake." *Environmental Health Perspectives* (submitted).

<Co-author><Co-author>, <Co-author>, and Reviewer E. "Great Lakes Sediment Quality Assessment Using Whole Sediment Toxicity Tests with Macroinvertebrates." *Great Lakes Journal*. (submitted)

Reviewer E (Continued)

- <Co-author>, <Co-author>, <Co-author>, <Co-author>, <Co-author>, Reviewer E, and <Co-author>. 1997. "Heavy Metal Accumulation in Freshwater Fish in U.S. Arctic Lakes." *Environmental Toxicology and Chemistry* 16(4):733-741.
- <Co-author>, <Co-author>, <Co-author>, <Co-author>, S. <Co-author>, Reviewer E, and <Co-author>. 1995. "Inorganic Contaminants in Arctic Alaskan Ecosystems: Long-Range Atmospheric Transport or Local Point Sources?" *The Science of the Total Environment* 160/161:323-335.
- <Co-author>, Reviewer E, and <Co-author>. 1994. "Temporal and Spatial Changes in the Concentrations of Hydrocarbons and Trace Metals in the Vicinity of an Offshore Oil Production Platform." *Marine Environmental Research* 37:129-163.
- <Co-author>, and Reviewer E. 1994. "The Relationship Between Acid Volatile Sulfide and the Toxicity of Zinc, Lead, and Copper in Marine Sediments." *Environmental Toxicology and Chemistry* 13(3):529-536.
- <Co-author>, <Co-author>, <Co-author>, <Co-author>, and Reviewer E. 1994. "Urinary Excretion Kinetics and DNA Damage in Normal and Choline Deficient Male B6C3F1 Mice Treated Once by Oral Gavage with Sodium Arsenite." *Environmental and Molecular Mutagenesis*, Volume 23, Supplement 23. Wiley-Liss.
- <Co-author>, <Co-author>, <Co-author>, <Co-author>, Reviewer E, <Co-author>, <Co-author>, <Co-author>, <Co-author>, <Co-author>, and <Co-author>. 1993. "Toxicity of contaminated sediments in Dilution Series with Control Sediments." *Chemosphere* 9:1789-1812.
- <Co-author>, <Co-author>, Reviewer E, <Co-author>, <Co-author>, and <Co-author>. 1992. "Fate of Bunker C Fuel Oil in Washington Coastal Habitats Following the December 1988 NESTUCCA Oil Spill." *Northwest Science* 66(1):1-14.
- Reviewer E, <Co-author>, <Co-author>, and <Co-author>. 1991. "Trace Metals in Sediments from the Inner Continental Shelf of the Western Beaufort Sea." *Environ. Geol. Water Sci.* 18:71-79.
- <Co-author>, <Co-author>, Reviewer E, <Co-author>, <Co-author>, and <Co-author>. 1990. "Monitoring Long-Term Effects of Offshore Oil and Gas Development Along the Southern California Outer Continental Shelf and Slope: Background Environmental Conditions in the Santa Maria Basin." *Oil & Chemical Pollution* 6:195-240.
- <Co-author>, <Co-author>, and Reviewer E. 1989. "Comparison of Two Gravity Coring Devices for Sedimentation Rate Measurement by 210-Pb Dating Techniques." *Hydrobiologia* 179:261-269.
- <Co-author>, <Co-author>, <Co-author>, Reviewer E, and <Co-author>. 1989. "Separate Dissolved and Particulate Trace Metal Budgets for an Estuarine System: An Aid for Management Decisions." *Environmental Pollution* 57:317-339.
- Reviewer E. 1988. "Detecting Contamination or Trends in the Concentrations of Trace Metals in Marine Environments." *Journal of Research of the National Bureau of Standards* 93:321-323.

Reviewer E (Continued)

<Co-author>, Reviewer E, <Co-author>, <Co-author>, <Co-author>, and <Co-author>. 1988. "Aquatic Surface Contamination in Chesapeake Bay." *Mar. Chem.* 28:333-351.

<Co-author>, <Co-author>, <Co-author>, Reviewer E, <Co-author>, and <Co-author>. 1988. "The Impact of Scavenging on Trace Metal Budgets in Puget Sound." *Geochimica et Cosmochimica Acta* 52:1765-1779.

<Co-author>, <Co-author>, <Co-author>, <Co-author>, <Co-author>, <Co-author>, and Reviewer E. 1988. "Contaminant Concentrations and Toxicity of Sea-surface Microlayer Near Los Angeles, California." *Mar. Environ. Res.* 23:307-323.

<Co-author>, Reviewer E, <Co-author>, <Co-author>, <Co-author>, and <Co-author>. 1988. "The Sea-surface Contamination in Puget Sound: Part II. Concentration and Distribution of Contaminants and Relation to Toxicity." *Mar. Environ. Res.* 23:227-249.

<Co-author>, Reviewer E, <Co-author>, and <Co-author>. 1988. "Toxicity - Metal Speciation Relationships for *Daphnia magna* Exposed to Brass Powder." *Arch. Environ. Contamin. Toxicol.* 17:575-581.

<Co-author>, <Co-author>, and Reviewer E. 1988. "Accumulation Rates of Recent Sediments in Puget Sound, Washington." *Marine Geology*.

<Co-author>, <Co-author>, Reviewer E, and <Co-author>. 1987. "A Laboratory Study of the Accumulation and Toxicity of Contaminants in the Sea Surface from Sediments Proposed for Dredging." *Mar. Environ. Res.* 23:325-338.

<Co-author>, and Reviewer E. 1987. "Distribution of Silver, Mercury, Lead, Copper and Cadmium in Central Puget Sound Sediments." *Marine Chemistry* 21:377-390.

<Co-author>, <Co-author>, Reviewer E, and <Co-author>. 1985. "Sea-Surface Microlayer Metals Enrichments in an Urban and Rural Bay." *Estuarine Coastal Shelf Sci.* 20:299-312.

<Co-author>, <Co-author>, Reviewer E, and <Co-author>. 1985. "The Sea-Surface Microlayer: Fate and Residence Times of Atmospheric Metals." *Limnol. Oceanogr.* 30(1):93-101.

<Co-author>, and Reviewer E. 1984. "Determination of Silver in Sea Water by Coprecipitation with Cobalt Pyrrolidinedithiocarbamate and Zeeman Graphite-Furnace Atomic Absorption Spectrometry." *Anal. Chim. Acta.* 156:139-145.

Reviewer E, <Co-author>, and <Co-author>. 1984. "Sediment Mass Balance for the Main Basin of Puget Sound." (Abstract) *Am. Geophys. Union Trans. EOS* 64:1104.

<Co-author>, <Co-author>, Reviewer E, and <Co-author>. 1984. "Transfer of Cadmium in a Phytoplankton-Oyster-Mouse Food Chain." *Arch. Environ. Contam. Toxicol.* 23:419-425.



Reviewer E (Continued)

<Co-author>, Reviewer E, and <Co-author>. 1984. "Polycyclic Aromatic Hydrocarbons in Washington Coastal Sediments: An Evaluation of Atmospheric and Riverine Routes of Introduction." *Environ. Sci. Technol.* 18:687-693.

<Co-author>, and Reviewer E. 1984. "Elemental Composition of the Hydrothermal Vent Clam, *Calyplogena magnifica*, from the East Pacific Rise." *Marine Biology* 83:155-161.

<Co-author>, <Co-author>, Reviewer E, and <Co-author>. 1984. "Distribution of Trace Metals in the Hydrothermal Vent Clam, *Calyplogena magnifica*." *Biol. Soc. Wash. Bull.* 6:311-324.

<Co-author>, and Reviewer E. 1983a. "Solubility Behavior of Atmospheric <sup>7</sup>Be in the Marine Environment." *Mar. Chem.* 12:323-331.

<Co-author>, and Reviewer E. 1983b. "Determination of Mercury in Seawater at Sub-Nanogram per Liter Levels." *Mar. Chem.* 14:49-59.

Reviewer E. 1982. "The Use of <sup>210</sup>Pb in the Comparison of Sedimentation Rates with Sediment Trap Flux for the Central Basin of Puget Sound." *Eos Am. Geophys. Union Trans.* 63(3):82. (Abstract).

Reviewer E, <Co-author>, <Co-author>, <Co-author>, <Co-author>, <Co-author>, and <Co-author>. 1982. "Copper Bioavailability to Marine Bivalves and Shrimp: Relationship to Cupric Ion Activity." *Mar. Environ. Res.* 6:13-26.

Reviewer E. 1981. "Prediction of Marine Atmospheric Deposition Rates Using Total <sup>7</sup>Be Deposition Velocities." *Atmos. Environ.* 15:579-582.

<Co-author>, and Reviewer E. 1981. "Is Atmospheric Particulate Matter Inhibiting Marine Primary Productivity?" *Environ. Sci. Technol.* 15:1103-1105.

Reviewer E. 1980. "The Solubility of Coal Fly Ash and Marine Aerosols in Seawater." *Mar. Chem.* 8:245-250.

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<Co-author>, <Co-author>, Reviewer E, <Co-author>. 1982. "Microcosm Studies of Metal-Enriched Atmospheric Particles and Neuston Communities." Presented at the Annual Meeting of the American Society of Limnology and Oceanography, June 14-17, 1982, Raleigh, North Carolina.

<Co-author>, Reviewer E, <Co-author>, <Co-author>, and <Co-author>. 1982. "Atmospheric Metals Flux and Enrichments in Model Sea-Surface Microlayers." Presented at Annual Meeting of the American Society of Limnology and Oceanography, December 7-15, 1982, San Francisco, California.

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Reviewer E 1980. "The Geochemical Behavior of Arsenic in Puget Sound." Department of Energy Workshop on Environmental Effects of Photovoltaic Energy Technology, June 17-20, 1980, Brookhaven, New York.

<Co-author> and Reviewer E. 1980. "Determination of Elemental Solubilities from Atmospheric Aerosols Using Instrumental Neutron Analysis and Seawater Leaching." Presented at the 10th Annual Symposium on Analytical Chemistry of Pollutants, Dortmund, Federal Republic of Germany.

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<Co-author>, Reviewer E, <Co-author>, <Co-author>, <Co-author>, and <Co-author>. 1980. "Halogenated Organic Pollutants in Water and Suspended Matter from Puget Sound." Presented at the American Chemical Society Meeting, August 24-29, 1980, Las Vegas, Nevada.

Reviewer E 1979. "Coastal Aerosol Chemistry Using Shipboard and Shore Sampling Sites." Presented at ACS/CSJ Chemical Congress, April 1-6, 1979, Honolulu, Hawaii.

Reviewer E 1979. "Comparison of Atmospheric and Riverine Transport of Trace Elements to the Continental Shelf Environment." Presented at Department of Energy Workshop on Processes Determining the Input Behavior and Fate of Radionuclides and Trace Elements in Continental Shelf Environments, March 7-9, 1979, Washington, D.C.

Reviewer E 1979. "Air Inputs of Chemicals to the Washington Coast." Presented at the Geochemical Oceanography Seminar, University of Washington, October 26, 1979, Seattle, Washington.

Reviewer E and <Co-author>. 1979. "Organisms and Trace Metals in the Water Column." Presented at NOAA/MESA Puget Sound Project Workshop, October 17, 1979, Seattle, Washington.

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<Co-author>, Reviewer E, <Co-author>, <Co-author>, <Co-author>. 1979. "Background Air Particulate Chemistry Near Colstrip, Montana." Presented at the 34th Northwest Regional Meeting/American Chemical Society, June 13-15, 1979, Richland, Washington.

Reviewer E 1978. "Analytical Techniques for Arsenic Species in Environmental Samples." Presented at the First Symposium on Environmental Analytical Chemistry, June 21-23, 1978, Provo, Utah.

<Co-author>, Reviewer E, <Co-author>, <Co-author>, and <Co-author>. 1978. "The Availability of Trace Metals in Sediments to Detrital-Feeding Organisms." Presented at the 41st Annual Meeting of the American Society of Limnology and Oceanography, June 19-22, 1978, Victoria, British Columbia, Canada.

Reviewer E 1978. "Deposition Rate of Airborne Particulate Elements on the Washington Coast." Presented at the 41st Annual Meeting of the American Society of Limnology and Oceanography, June 19-22, 1978, Victoria, British Columbia, Canada.

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Reviewer E 1978. "Measurement of Oxidants in Ozonated Sea Water and Some Biological Reactions." Presented at the Second Workshop on Marine and Freshwater Application of Ozone, November 1-3, 1978, Orlando, Florida.

<Co-author>, <Co-author>, <Co-author>, <Co-author>, Reviewer E, and <Co-author>. 1978. "A Chemical Characterization of Pollutants Released During Geothermal Energy Development." Presented at Annual Meeting of the Association for the Advancement of Science, February 12-17, 1978, Washington, D.C.

Reviewer E, <Co-author>, <Co-author>, and <Co-author>. 1978. "Trace Element Radionuclide Emissions from the Colstrip, Montana, Coal-Fired Power Plant." Presented at the 22nd Annual Conference on Analytical Chemistry in Energy Technology, October 10-12, 1978, Gatlinburg, Tennessee.

Reviewer E 1978. "Detailed Chemical Characterization of Coal Fly Ash Leachates." Presented at the EPRI Workshop on Fly Ash and Its Leachates, May 24-26, 1978, Palo Alto, California.

<Co-author> and Reviewer E. 1977. "Copper Speciation in Sea Water Determined by Anodic Stripping Voltametry." Presented at Association for the Advancement of Science Meeting, February 23-25, 1977, Denver, Colorado.

<Co-author>, <Co-author>, and Reviewer E. 1977. "Bioavailability of Hydrocarbons and Heavy Metals to Marine Detritivores from Oil-Impacted Sediments (RU 454)." Presented at the Workshop on Marine

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Biological Effects of OCS Petroleum Development, A Program Review of Research Supported Under the NOAA Outer Continental Shelf Environmental Assessment Program, November 29-December 2, 1977, Seattle, Washington.

Reviewer E 1977. "The Production of Bromine, Bromate and Chlorine in Sea Water by Ozonation." Presented at the Symposium on Advanced Ozone Technology, November 2-4, 1977, Toronto, Canada.

<Co-author>, Reviewer E, <Co-author>, and <Co-author>. 1977. "Heavy Metal Emissions from Geothermal Power Plants." Presented at 2nd Workshop on Sampling and Analysis of Geothermal Effluents, February 15-17, 1977, Las Vegas, Nevada.

Reviewer E 1976. "Changes in the Chemical Speciation of Arsenic Following Ingestion by Man." Presented at the International Institute of Environmental Health Science and Department of Environmental Hygiene, Karolinska Institute, October 5-8, 1976, Fort Lauderdale, Florida.

Reviewer E 1976. "The Montana Coal-Fired Power Plant Project." Presented at meeting sponsored by the Corvallis Environmental Research Laboratory, November 14, 1976, Corvallis, Oregon.

<Co-author>, Reviewer E, and <Co-author>. 1976. "Airborne Arsenic Exposure and Excretion of Methylated Arsenic Compounds." Presented at International Institute of Environmental Health Science and Department of Environmental Hygiene, Karolinska Institute, October 5-8, 1976, Fort Lauderdale, Florida.

<Co-author>, <Co-author>, Reviewer E, and <Co-author>. 1975. "Heavy Metal Mobilization from Geothermal Areas." Presented at Geothermal Environmental Seminar, November 14, 1975, Lakeport, California.

Reviewer E, <Co-author>, and <Co-author>. 1975. "The Development and Characterization of Marine Standard Reference Materials (SRMS) for Chemical Speciation Determinations." Presented at the Workshop on Standard Reference Materials for Marine Science, sponsored by National Bureau of Standards, October 8-10, 1975, Catalina Island, California.

Reviewer E 1974. "The Geochemical Cycle of Arsenic in Lake Washington, Seattle." Presented at the 37th Annual Meeting of the American Society of Limnology and Oceanography, June 23-28, 1974, Seattle, Washington.

**APPENDIX F**

**Reviewer F Curriculum Vitae**

## Reviewer F

<Affiliation, Address, and Telephone Number Removed>

### EDUCATION

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<u>Institution and Location</u>	<u>Degree</u>	<u>Date</u>	<u>Field</u>
Cornell University, Ithaca, NY	Ph.D.	1971	Analytical Chemistry
Cornell University, Ithaca, NY	M.S.	1969	Analytical Chemistry
Univ. of Massachusetts, Amherst, MA	B.S.	1967	Chemistry

### HONORS

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Editorial Board, American Environmental Laboratory, 1990 to 1999  
Editorial Advisory Board, GC/MS Update - Part A, 1994 to 1998  
Industrial Advisory Council, SDSU Department of Chemistry - 1982 to 1988  
EPA Certificate of Appreciation - 1980  
IR-100 Award - 1975  
Society of Sigma Xi - 1971  
DuPont Teaching Prize - 1970  
Graduation with Honors in Chemistry- 1967

### PROFESSIONAL EXPERIENCE

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#### 1985 - Present:

<Affiliation Removed>. Established business now operating at a rate of approximately \$2000k/yr using personal resources. Responsible for all business activities including chemical analysis services and special projects, software development, marketing and finance. The technical activities of PA include environmental analytical methods development and environmental analysis services for commercial and government clients. Significant developments have included analytical methods for determining TCLP analytes in waste oil, sub-ppb detection for organic pollutants in waste water and procedures for determining chemicals of concern in oily wastes. From 1985 through 1996, he has also provided consulting services to VG Masslab in the area of GC/MS software development. During this time he was responsible for the design concepts of the Lab-Base and MassLab GC/MS data systems.

#### 1977 - 1985:

Manager, Chemistry Program S-CUBED, a Division of Maxwell Laboratories, La Jolla, CA 92038. Responsibilities included: 1) line management of 30 people (6 Ph.D.s, 1 M.E., 1 E.E., 18 B.S.s), 2) technical and fiscal management for >\$2500k/yr in contract revenues, and 3) marketing for the Chemistry Program. Technical activities managed included environmental analytical methods development, environmental analysis services for EPA, quality assurance support to EPA and instrument development for the US Army and Navy. Significant projects included the development of an

atmospheric pressure ionization pulsed molecular beam mass spectrometer, development of EPA Methods 1624 and 1625 (see Federal Register), plus sampling and analysis methods for monitoring hazardous waste incineration.

**1976 - 1977:**

Senior Research Associate, Division of Neuroscience, City of Hope National Medical Center, Duarte, CA. Developed of qualitative and quantitative methods for GC/MS; provided access to newly developing analytical technologies as they related to problems in the neurosciences. Specific research interests included determining selected neurotransmitters in single cells dissected from the mollusk *Aplysia*.

**1974 - 1976:**

Research Chemist, Instrument Products Division, E.I. DuPont de Nemours, Monrovia, CA. Development of a new integrated GC/MS system; initial system design including GC and accessories, C/CI source detection system and selected digital control systems. (From 1976 through 1983 he served as a consultant to this group on an annual retainer basis.)

**1971 - 1974:**

Research Chemist, Materials Research Laboratory, University of Illinois, Urbana, IL. Solved problems related to materials characterization using mass spectrometry (SIMS and SSMS); mass spectrometry research. Studies included the self diffusion of silicon, crack propagation, hydrogen embrittlement and degradation of synthetic ceramic implants in teeth. Studies were also preformed in the area of electrohydrodynamic ionization.

## **PATENTS**

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"Automated PCB Analyzer System", No. 4,944,921, July 13, 1990, Reviewer F and E.A. Burns.

"Extraction of Organic Pollutants from Process Waters", No. 3,578,502, May 21, 1985, E.A. Burns and Reviewer F. (22 claims).

"Methods and Apparatus for the Elemental Analysis of Solids", No. 4,166,952, September 4, 1979, Reviewer F and C.W. Hull. (10 claims).

"Analytical Apparatus with Variable Energy Ion Beam Source", No. 4,016,421, April 5, 1977, C.W. Hull, T.W. Whitehead and Reviewer F. (26 claims).

## **PUBLICATIONS**

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Reviewer F and <Co-author>, "Determination of Polynuclear Aromatic Hydrocarbons in Coal Tar Contaminated Soil at 1 ug/kg", Hydrocarbon Contaminated Soils, Volume 5, P.T. Kostecki, E.J. Calabrese and M. Bonazountas, Eds., Amherst Scientific Publishers (1985).

Reviewer F, "Deconvolution of Overlapping GC/MS Spectra", J Am Soc Mass Spectrom, 3, 558 (1992).

Reviewer F and <Co-author>, "Establishing Destruction for Hazardous Waste Incinerators", in "Quality Assurance for Environmental Measurements", ASTM STP867, 1985.

Reviewer F, <Co-author> and <Co-author>, "Strategies for Compound Identification and Quantification Using Fused Silica Capillary Column GC/MS", J. of High Res. Gas Chrom., 6, 72 (1983).

Reviewer F, <Co-author>, <Co-author>, and <Co-author>, "Isotope Dilution Gas Chromatography Mass Spectrometry for the Determination of Priority Pollutants in Industrial Effluents", J. Env. Safety, 1, 8 (1982).

Reviewer F, <Co-author> and <Co-author>, "Measurement Parameter Selection of Quantitative Isotope Dilution Gas Chromatography/Mass Spectrometry", Anal. Chem., 53, 1907 (1981).

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Reviewer F and <Co-author>, "Determination of Priority Pollutants in Industrial Wastewater by Stable Isotope Dilution - Gas Chromatography/Mass Spectrometry", Advances in the Identification and Analysis of Organic Pollutants in Water, L.H. Keith, Ed., Ann Arbor Science Publishers, Inc., Ann Arbor, Michigan (1981).

<Co-author> and Reviewer F, "Reduction in Sample Foaming in Purge and Trap Gas Chromatography/Mass Spectrometry Analysis", Anal. Chem., 51, 2176 (1979).

<Co-author>, Reviewer F and <Co-author>, "Gamma-Aminobutyric Acid in Ganglia and in Single Neurons from Aplysia and Lobster", J. Neurochem., 33, 967 (1979).

Reviewer F and <Co-author>, "A Comparison of Calculation Procedures for Isotope Dilution Determinations Using Gas Chromatography/Mass Spectrometry", Biomed. Mass Spectrom., 6, 225 (1979).

Reviewer F and <Co-author>, "A Highly specific and Sensitive Determination of GABA by GC/MS", Biomed. Mass Spectrom., 5, 215 (1978).

Reviewer F, "Mass Spectrometry: Instrumentation", Physical Methods in Modern Chemical Analysis, Volume 1, T. Kuwana, Ed., Academic Press, New York (1978).

<Co-author>, <Co-author>, Reviewer F and <Co-author>, "The Hollow Cathode Ion Source: Sensitivity and Cathode Geometry", Anal. Chem., 48, 118 (1976).

<Co-author>, Reviewer F and <Co-author>, "High Resolution Ion Microprobe Mass Spectrometry of Complex Matrices", Anal. Chem., 47, 1532 (1975).

<Co-author>, Reviewer F and <Co-author>, "Electro-hydrodynamic Ionization Mass Spectrometry - The Ionization of Liquid Glycerol and Non-Volatile Organic Solutes", J. of Mass Spectrom. and Ion Phys., 15, 291 (1974).

Reviewer F and <Co-author>, "Electrohydrodynamic Ionization Mass Spectrometry", Advances in Mass Spectrometry, Vol. 6, p. 585, A.R. West, Ed., Applied Science Publishers, Ltd., Barking Essex, England, 1974.

Reviewer F and <Co-author>, "Hollow Cathode Ionization for the Mass Spectrometric Analysis of Conducting Solids", Anal. Chem., 46, 1236 (1974).

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Reviewer F and <Co-author>, "Spectral Interferences in Secondary Ion Mass Spectrometry", Applied Spectroscopy, 27, 274 (1973).

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<Co-author> and Reviewer F, "Precision of Electrical Detection Measurements of Powdered Samples in Spark Source Mass Spectrometry", Anal. Chem., 44, 1206 (1972).

<Co-author>, Reviewer F and <Co-author>, "On-Line Computer Controlled Electrical Detection in Spark Source Mass Spectrometry", Anal. Chem., 44, 1203 (1972).

## **RECENT LECTURES**

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"Comparison of Results of PCB Determinations Using HRGC/LRMS and HRGC/HRMS", 23<sup>rd</sup> Annual Conference on Analysis of Pollutants in the Environment, Pittsburgh, PA, June, 2000 (Invited).

"Sorption of Semi-Volatile Organic Compounds to the Inner Surface of Sample Bottles", 23<sup>rd</sup> Annual Conference on Analysis of Pollutants in the Environment, Pittsburgh, PA, June, 2000 (Invited).

"Detectability of Semi-volatile Pollutants by GC/MS with Software Thresholds On and Off", 22<sup>nd</sup> Annual Conference on Analysis of Pollutants in the Environment, Philadelphia, PA, June, 1999 (Invited).

"Initial Validation of Method 1668, Toxic PCBs by HRGC/HRMS", 19<sup>th</sup> Annual Conference on Analysis of Pollutants in the Environment, Norfolk, VA, May, 1996 (Invited).

"Performance Evaluation Samples", 1995 International Chemical Congress of Pacific Basin Societies, December, Honolulu, HI, 1995 (Invited).

"Environmental Data Validation - Is There a Problem?", 1<sup>st</sup> International Validation Forum Conference, Williamsburg, VA, May, 1995 (Invited).

"Dioxin/Furan Analysis", 43<sup>th</sup> ASMS Conference on Mass Spectrometry and Allied Topics, Atlanta, GA, May, 1995 (short course).

"Semivolatiles Analysis in the Real World", 43<sup>th</sup> ASMS Conference on Mass Spectrometry and Allied Topics, Atlanta, GA, May, 1995 (short course).

"Solid Phase Micro-Extraction for the Analysis of Wastewaters", 18<sup>th</sup> Annual Conference on Analysis of Pollutants in the Environment, Norfolk, VA, May, 1995 (Invited).

"Volatile Organic Hydrocarbon Measurements", 1<sup>st</sup> Annual Conference on Hydrocarbon Contaminated Soils: Expediting Cleanups, New Orleans, LA, January, 1995 (Invited).

"Determination of Polynuclear Aromatic Hydrocarbons in Coal Tar Contaminated Soils at 1 ug/kg", 9<sup>th</sup> Annual Conference on Contaminated Soils, Amherst, MA, October, 1994 (Invited).



"Background Subtraction Techniques and Library Search Reliability", 13<sup>th</sup> International Mass Spectrometry Conference, Budapest, August, 1994.

"Designer GC/MS Data Systems", 42<sup>th</sup> ASMS Conference on Mass Spectrometry and Allied Topics, Chicago, IL, May, 1994.

"Dioxin/Furan Analysis", 42<sup>th</sup> ASMS Conference on Mass Spectrometry and Allied Topics, San Chicago, IL, May, 1994 (short course).

"Semivolatiles Analysis in the Real World", 42<sup>th</sup> ASMS Conference on Mass Spectrometry and Allied Topics, Chicago, IL, May, 1994 (short course).

"Isotope Dilution HRGC/LRMS Volatiles Analysis", 17<sup>th</sup> Annual Conference on Analysis of Pollutants in the Environment, Norfolk, VA, May, 1994 (Invited).

"Solid Phase Microextraction for Environmental Sample Analysis", Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy, Chicago, March, 1994.

## **PROFESSIONAL SOCIETIES**

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American Chemical Society

American Society for Mass Spectrometry

## APPENDIX G

### Reviewer A Comments

Peer Review of *Plan for Assessment of Detection and Quantitation  
Limits Under Section 304(h) of the Clean Water Act*

Reviewer A, Ph.D.

- 1) The assessment approach is conceptually sound. The list of issues in Item 3 is sufficient. I have some comments below on what I think to be the most significant, high-priority issues.
- 2) Here are some of what I think to be the most important criteria for lower limits of analytical procedures:
  - a) Definitions should be consistent, scientifically meaningful, and statistically valid. For some specific comments on this issue, see below.
  - b) Procedures that implement the definitions should be clear and well defined. They should also implement the definition.
  - c) The data used to establish specific limits should be realistic. For example, if matrix effects are presumed to be important, then matrix spikes rather than reagent water spikes should be used.
  - d) There should be no artificial limits. Each defined and implemented limit should be based on a scientific and statistical analysis of the true limits of knowledge, not on preferences of involved parties for higher or lower levels. If we can measure something and provide an estimated standard deviation, then we should be able to use the data in science and in regulation.
- 3) I believe that the EPA should take a fresh look at all of the suggested definitions and procedures. It is correct to evaluate suggestions from the scientific literature, from standards organizations, and from other organizations. However, it may be that none of these procedures meets the criteria of 2), and meeting those criteria is far more important than precedent.
- 4) I am familiar with some of the data sets proposed, but not all of them. Data sets for a procedure like this one should have several to many replicates at a number of concentrations from zero or near zero, to near the critical level (see below) to high concentrations.
- 5) It is better to develop selection criteria during the development of the project. However, possible criteria should be included in the plan.

## Other Comments

The entire issue of lower limits of analytical methods is one that has been fraught with intellectual confusion, even when it has not been politically and economically controversial. The term "detection limit" has been used for a number of dissimilar concepts, and this has led to further confusion. For the purpose of this review, I will use a version of Currie's terminology.

The *Critical Level* is an observed value of the response (such as peak area) or equivalently, of the estimated concentration which would occur by chance in a sample in which the analyte was not present only a specified fraction of the time, say 1%. As with any such limit or level, it can depend on the entire analytical method, but is a well defined construct. This is the limit that tells the analyst when detection has occurred. Such detection is almost always quantitative, so long as there is a measured value and a standard error.

The *Minimum Detectable Quantity* is the smallest true concentration of the analyte such that with specified probability, such as 99%, the estimated concentration after measurement will exceed the critical level. This level has no interpretation once measurement has occurred. It is useful for planning, but not for interpretation of existing measurements.

For example, if the standard deviation at zero or a low level of an analyte is 2ppt exactly, then the critical level at 99% confidence is, using the normal percentage point,  $(2.326)(2) = 4.652$ . If the standard deviation is estimated, say by a sample of 7 replicates, then one would use the t distribution with 6 degrees of freedom so that the critical level would be  $(3.143)(2) = 6.286$ . Using the latter value for illustration, the practical use of the critical level of about 6ppt is that any measured concentration exceeding that demonstrates that the analyte is present in non-zero quantities. If we have a measured value of 8ppt, for example, then the standard deviation (assuming that it is constant over the range) is 2ppt, so a 95% confidence interval for the true concentration is (using the t distribution again) is  $8\text{ppt} \pm (2.447)(2)\text{ppt}$  or approximately (3ppt, 13ppt). This is a quantitative assessment. We know the true concentration to within 5ppt, which is pretty accurate. The coefficient of variation ( $2/8 = 25\%$ ) is not a relevant measure as to whether we have a quantitative measurement of the concentration.

If we use 99%/1% also for the minimum detectable quantity, and if we assume that within the range up to this level the standard deviation of measurement is approximately constant, then the minimum detectable quantity is twice the critical level. In the case illustrated above, this would be twice 6.286, or about 11ppt. This value of 11ppt might be a good spike concentration for quality control, because it should almost always generate a detection signal. However, it provides no information useful in interpreting a measured value of, say, 8ppt.

Glaser et al. (1981), along with many others, have seriously confused the issue. Consider the oft quoted definition of the MDL: "...the minimum concentration of a substance that can be identified, measured, and reported with 99% confidence that the analyte concentration is greater than zero..." The first half of this definition refers to an actual concentration, like the minimum detectable quantity, but the second half treats it as a measured value like the critical level. Clearly, we understand this better than we did in 1981. What the MDL estimates is the critical level, which is the threshold of detection, and it therefore should not be described as an actual concentration.

EPA should use the review that they are engaged in to clarify these issues, and to provide lower limits that are scientifically and statistically valid. In the first place, this means distinguishing carefully between the critical level and the minimum detectable quantity, and specifying when each one is to be used.

Another issue that deserves a hard look and a scientific analysis is that of the so-called limit of quantitation. For an analytical measurement to be quantitative, there are two requirements. First, there needs to be an estimated quantity produced by a known analytical procedure. Second, there needs to be an estimate of the precision of this measurement. Modern metrological techniques (Rocke and Lorenzato 1995; Zorn, Gibbons, and Sonzogni 1997) can provide the precision estimates at all measured values of an analyte. Thus, any measured value by a calibrated system is quantitative, and there is no such thing as a limit of quantitation if it is defined by standard deviation, coefficient of variation and the like. The only scientifically valid definition is akin to the original ML of 1984. If the instrument cannot produce a number, then we are below the limit of quantitation. This will usually be because the peak cannot be identified that should be integrated to produce the estimated concentration.

The procedures provided by EPA and the questions to be examined will be sufficient to deal with these and other issues, so long as the attention is focused on scientifically and statistically valid methods. This review provides an opportunity for EPA to clarify these vexed issues, and provide unambiguous, practical, interpretable, and valid methods for lower limits of analytical methods.

The plan itself seems comprehensive and well thought out. All important issues will be considered in the process. Of course, the most important proof of the soundness of the plan for assessment will be the product of the assessment to follow. At this stage, I believe that EPA has provided a procedure that can address all of the facets necessary to produce a scientifically and statistically valid re-examination of the issue of lower limits for analytical measurements.

## **APPENDIX H**

### **Reviewer C Comments**

## **Review of Plan for the Assessment of Detection and Quantitation Limits Under Section 304(h) of the Clean Water Act**

Reviewer C

### **General comments**

I think the plan is very thorough, with the various events called for touching on many important issues, and I can't find anything that seems to have been overlooked. The issues considered deal with the legal aspects of the situation, and also with doing good science and searching for a reliable MDL determination procedure.

### **Response to questions in the technical charge**

1) Evaluate the conceptual soundness of the assessment approach presented in the study plan. Is the list of issues included in Item 3 of the study plan sufficient? Are there other significant issues that EPA should add or delete? How should the EPA prioritize the issues? --- Events 3 through 8 give chief steps in the assessment approach which is proposed. These seem to thoroughly cover many relevant issues. Key to the assessment plan is Event 3, since so many important issues are identified. Giving adequate attention to these issues up front should help to insure that the key issues are understood so that careful choices can be made before the evaluation and selection begins. I can't think of anything to add to the list for Event 3. At the same time, I'd be hesitant to delete anything at this point, although I think that it will be the case that some issues will be found to be not nearly as complex as other issues, and that these simpler issues can be addressed somewhat quickly.

With regard to prioritizing the issues listed for Event 3, items a, b, f, and o seem to be important and may also require more time than some of the other items. However I suspect that at least some parts of the literature review are well underway (or complete). Still, it will be very important to take the results of the literature review and carefully organize and summarize the material (as opposed to just providing a lengthy listing of issues and proposed methods), and this may prove to be a rather difficult job. Item f deals with the experimental design of the studies that will be performed to test various methods. This seems to be a very important part of the overall plan, since the design should take into account many important issues that are identified in completing the many other items of Event 3. Overall, it seems that a large-scale and carefully performed experimental comparison of a good number of well selected methods will be how one finds out which methods are the most accurate. Since time and resource constraints always tend to limit the size of studies that are to be performed, it is important to use a good design in order to produce the most effective results. Items b and o touch upon legal and regulatory concerns, and thus may be somewhat complex.

Important items which might not be so time consuming include items e and i. Item e deals with the development of detection/quantitation procedures based on statistical tolerance and prediction. Item i, which calls for consideration of false positives and false negatives, shouldn't take much time, but it is of the upmost importance since the definition of MDL utilizes the probability of a false positive. False negatives are also important, since they are cases where contaminants are present, but a nondetect is recorded. Since false results are such a key issue, it will be important that they are carefully considered when the experimental design is developed. For example, if the false positive rate is to be controlled to be no greater than 0.01, then a large number of trials under the null hypothesis condition of no analyte present must be performed to accurately assess whether or not the false positive rate is adequately controlled. Also, one needs to carefully consider the various ways in which hypothesis testing can be used in the assessment. If the null hypothesis is taken to be  $p \leq 0.01$ , where  $p$  is the probability of a false positive resulting from a particular MDL method, then one has to keep in mind that a failure to reject does

not provide statistically significant evidence that  $p \leq 0.01$ , since a failure to reject could be due to low power, resulting from too few experimental trials. To truly protect against a method having a false positive rate exceeding 0.01, one may wish to make  $p > 0.01$  the null hypothesis and  $p \leq 0.01$  the alternate hypothesis. It can get to be a bit confusing, since there are two different null hypothesis situations (at two different levels): the null situation of no analyte present, for which we are concerned about the false positive rate of an MDL method, and the null hypothesis that when no analyte is present, the false positive rate is greater than 0.01, in which case a type I error would be a claim that the rate is less than or equal to 0.01 when in fact it is not.

While I do not think that items c, d, and m are by themselves unimportant, I do think that it's important to view them as being linked, and to keep in mind that the main concern is to determine which methods for determining the MDL have the greatest accuracy, and not which methods and models are best for a particular stage in the overall determination of the MDL. This is particularly true if the model upon which a method is based is only a loose approximation of reality, in which case the interpretation of parameters may be viewed as being rather fuzzy. In the end, it's whether or not a particular method is reasonably accurate --- viewing the performance of the overall method, and not examining too closely each of its components. Rather than spend so much time on model selection and assessment, and parameter estimation, it may be better to put more resources into the testing stage, and thoroughly test a large number of methods which have been proposed by others. However, I do think that some thought can go into parameter estimation. For example, if one is uncertain about how to identify and handle outliers, one could replace the commonly used sample standard deviation (it's used in Method 1631B) with a more robust measure of scale. But again, it's important to keep in mind the overall goal of finding an accurate way to determine the MDL. It's not so important to know whether or not a robust measure of scale is a better estimator in the traditional sense of estimating a true distribution parameter accurately. Rather, what is important is finding out whether or not replacing the sample standard deviation with a robust measure improves the performance of the overall determination of the MDL. Fortunately, in some cases, using alternative estimators, in addition to the one originally proposed for use with a particular method, won't require that additional observations be made, but will only require that alternate determinations of the MDL be made using the same set of data.

2) Based on your understanding of the issues, are there types of criteria that you suggest EPA include to evaluate detection and quantitation procedures? If yes, please identify the criteria and provide rationale for its inclusion. --- I think that the main focus should be the probability of a false positive result in the null case of no analyte present. This probability should be as close as possible to the allowable limit (say 0.01) without going over the limit. While exceeding the limit is particularly bad, since false detections could result in lawsuits and also contribute to a lack of confidence in water quality studies, being too far under the limit, which results from MDL determinations that are larger than they need to be, hurts the power of the method to detect the analyte when it is present. Alternatively, and perhaps nearly equivalently, one can view the situation in terms of both false positives and false negatives, with a goal being to find the method with the smallest false negative rate that also satisfies the false positive criterion. The trouble with this approach is that the false negative rate will almost surely depend on how much analyte is present, and one method may be better than another at low levels while the opposite is true at higher levels. (Putting it in statistical terms, there may not be a uniformly most powerful test.)

It should be kept in mind that the methods will be used in a variety of settings, and so the null situation of no analyte present should be tested with a variety of water sources. If one observes differing false positive rates for the variety of water sources (all having no analyte present), then rather than average all of the observed false positive rates, I think it may be prudent to focus on the highest value and require that it satisfy the false positive criterion, since one will want to believe that the false positive rate limit is adhered to no matter what the circumstances (within reason) may be.



In addition to focusing on the false positive rate, which is tied to the definition of the MDL, I also think that the MDL values from the various methods investigated should be compared to an estimate of the 99th percentile of the null distribution, by which I mean the distribution of determinations obtained in the case of no analyte present. It seems to me that the 99th percentile of this distribution could be viewed as a value for the MDL. Using any value less than this 99th percentile as the MDL would mean that if no analyte were present, the probability of obtaining a measured concentration greater than the MDL would exceed 0.01, and thus violate Glaser's definition (which is also the definition given in Appendix B to Part 136). To estimate the 99th percentile of the null distribution, a simple nonparametric quantile estimator could be used (with the choice of estimator being dependent on the shape of the distribution and the number of observations (where here each observation is a determination of the concentration of analyte from a sample in which no analyte is present)). It should be kept in mind that in order to get a decent estimate of the 99th percentile of a distribution, it may take several hundred observations. So this method of determining the MDL may be impractical for ordinary use. But perhaps it can be used as a spot check in at least a small number of cases.

I think claims made in the literature about various methods should not be used to judge them, since previous investigations of accuracy were not done the same way for all of the methods. Instead, the determination of the most reliable methods should be based on the results of a large well-designed and properly executed experiment (or series of experiments).

Finally, with regard to criteria, some weight has to be put on simplicity and ease of use. The method(s) selected will be used by a large number of people, and some will be more skilled than others.

3) What existing detection and quantitation procedures should EPA evaluate or focus on? Procedures from the open literature? Voluntary consensus standards procedures? Procedures from other organizations? --- Of course, methods currently used by the EPA, such as Method 1631B, should be included. In addition, I'm in favor of including several promising methods that are to be identified from the open scientific literature, as well as perhaps a small number of alternate procedures that are used by other organizations, provided that some justification can be found for them other than that they are sometimes used. (I fear that sometimes a method can become popular for no real good reason. One organization may select a method for use somewhat haphazardly, and then another organization can pick up the method just because others have used it. Since methods are sometimes selected based in part on political considerations, or concerns about practicality that may not be pertinent in all cases, I tend not to give a lot of weight to the popularity of methods, and I'm much more impressed by studies, performed by people other than the originators of the method, that demonstrate that a method is reasonably accurate.)

Methods from the literature are nice to consider, because as time passes, refinements seem to be made upon previously proposed methods, and one can be hopeful that the class of methods that get the most attention of this sort are the ones that perform best, and thus hope that recent papers giving the latest adjustments to an established general scheme will include some that are (near) state-of-the-art. Of course, one has to be wary of authors who are too eager to publish and develop a small adjustment in hope of getting a quick and easy publication. Also, since many published methods seem to be highly derivative of previously published ones, there might not be enough variety found in the literature and so one may want to consider other sources.

With regard to identifying alternate methods from the literature review, I think that the 1998 memorandum from Raphael Kuznetsovski of SAIC should be of great help. There are 27 papers and books described in the method detection limits and quantification section. The summaries provided for each of the 27 works can be used to narrow the focus to perhaps a dozen or fewer key entries worthy of careful consideration. In general, I recommend examining recent articles, slightly older articles from the chemistry literature by authors who are well established in the field, and also articles from the statistical literature in order to perhaps gain a slightly different perspective.

I'll now make some brief comments about some of the works described in the SAIC memo. (Since complete citations are provided in that memo, I won't duplicate such information here.) Several of the papers pertain to the Hubaux and Vos approach: the original 1970 paper, the 1978 paper by Bayley, Cox, and Springer, and the 1997 paper by Coleman, Auses, and Grams, with this last paper being by far the most recent of the three, and perhaps worthy of a close look. Gibbons has written a lot of pertinent articles, and I think several of his works should be studied, particularly those which compare various methods, like his 1994 book. Similarly, Currie has written a lot, but some of his work is rather dated, and some of it deals with related issues and not particular methods. But his 1997 paper may be of interest, since it touches on assumptions and approximations. Davis' 1994 article, the 1991 paper of Lambert, Peterson, and Terpenning, and the 1997 paper of Spiegelman and Tarlow are examples of works from the statistical literature that could be of interest, and the 1987 paper of Clayton, Hines, and Elkins and the 1988 paper of Garner and Robertson are papers from the chemical literature that could be considered, with the later paper of particular interest since it touches on the issue of assumptions.

Finally, I think that it will be important to consider variety with regard to the complexity of the methods to be chosen. It might be good to include some simple methods in addition to those which are rather involved. Not only are the more complex methods more difficult for some to accurately use, but it may be the case that some of the simpler methods could outperform some of the complex ones, due to poor assumptions underlying some of the methods.

4) Are the data sets listed in the plan appropriate for use in the detection and quantitation reassessment? Are there other data sets that you recommend EPA evaluate? --- Based on my rather limited knowledge about the data sets referred to, they do seem appropriate for use. At this time, I don't have any other data sets to recommend. However, it may be good to produce some new data for this important study, since existing data may not be ideal.

5) Is it appropriate to include specific selection criteria in the plan or is it more appropriate to develop selection criteria based on the analysis of issues that will be conducted as part of the plan? --- I believe that it is better to firm up the selection criteria as the study progresses, thinking that people will develop a better understanding of the issues as they put more thought into them. Plus, instead of specifying the criteria up front, it may be better to wait and see what happens and then examine the pros and cons of the various methods when making specific comparisons.

### **Specific comments**

In the schedule given on page 12 some events seem out of sequence. From pages 8 and 9 it seems as though Events 5 and 6, which deal with evaluation and reassessment, should follow Event 4, which is criteria development, and this seems sensible to me. Yet on page 12, it appears as though Event 4 lags behind Events 5 and 6.

## New information

This doesn't pertain explicitly to the 12 page plan. But in reviewing supplementary material that was sent to me along with the plan, I noticed a few typos in Appendix B to Part 136. The most serious mistake is in part (b) of Step 7. If the ratio of variances is less than 3.05, then one would compute the pooled standard deviation. So the first  $>3.05$  should be  $<3.05$ . (One can check this in the original description of the method given in the 1981 paper by Glaser, Foest, McKee, Quane, and Budde.) Less serious are two minor typos: (i) below the sum at the bottom of page 2 it should just be  $i = 1$ , not  $i = 1S$ ; (ii) on the 3rd line of page 3,  $S$  should be replaced by a sigma.

I'll also comment that I'm a bit suspicious of Method 136B. The justification given for the approach in the paper by Glaser et al makes use of assumptions and approximations. Since the final formula given for the MDL doesn't seem quite right. I wonder if perhaps too many assumptions were made along the way. Also, distribution skewness could harm the accuracy of the method.

## References

I don't have any additional references to suggest.

## **APPENDIX I**

### **Reviewer E Comments**

## Review of ``Plan for the Assessment of Detection and Quantitation Limits Under Section 304(h) of the Clean Water Act

Reviewer E, Ph.D.

### General Comments

The "environmental chemistry" community has been using the Fed. Reg. MDL method for about 10 years to demonstrate detection limits. I feel this is an acceptable approach.

Each EPA method should include a statement about the range of MDLs that have been demonstrated during the validation of the method. Each EPA method should state that any lab using this method must demonstrate their own MDL, which may be higher or lower than the range mentioned in the method.

The labs can inform their "clients" about their lab MDLs and the "environmental chemistry market" will drive these MDLs. If a regulation requires low detection limit then labs will be motivated to demonstrate the needed MDL.

Another decision EPA needed to make is to define the factor that is used to convert the MDL to a Reporting Limit, or what ever it will be called. For example if the RL or ML is defined as 3.18 times the MDL then everyone could understand and use it even though they may not agree.

### Specific comments

The only document that was sent that I have any comments on is the 12 page "Plan for the Assessment of Detection and Quantitation Limits Under Section 304(h) of the Clean Water Act, dated 12-10-2001. The other materials are fine.

#### Page 4. Section ii. Method Development and Promulgation

I strongly believe that detection limits should not be cast in stone when the method is promulgated. The DL's often improve radically as labs become more proficient and improvements are made to techniques. I have experienced clients and regulators who flag data as below the DL because it is below the Method-specified DL but well above our achieved DL!

#### Page 5 Section vii. Descriptive versus Prescriptive Uses of Lower Limits to Measurement

I am very much in agreement with this statement which I assume means that the detection limit can change depending on the measurement method and the proficiency of the Lab.

#### Page 6 Section j. Measurement Quality Over the Life of a Method

I agree with this statement that the measurement quality will usually improve over the life of the method. This is a very important issue and therefore the DL for a method should be allowed to change as the equipment and analyst change.

Page 7 Section. m. Outliers

The term "outliers" is confusing as used in the statement. My understanding of outliers are data points that can be separated from the other data points with a statistical test called an "outlier test". There should be an acceptable procedure to determine when data is not appropriate to be included in an MDL.

Page 8 Section t. Cost to Implement Limit Procedures

A procedure for developing "theoretical MDL's" for solids, such as sediment and tissue, based on liquid MDL's should be explored. For example a true MDL for mercury in fish tissue can not be experimentally determined because all fish tissue has relatively high levels of mercury compare to the sensitivity of the method. However, using water derived MDL it is possible to calculate the MDL for fish. This situation is true for many metals that are naturally abundant in sediment, soil and tissue.

**Response to questions in the technical charge**

(1) Evaluate the conceptual soundness of the assessment approach presented in the study plan. Is the list of issues included in Item 3 of the study plan sufficient? Are there other significant issues that EPA should add or delete? How should EPA prioritize the issues?

I think the Plan is sufficient and would prioritize the need for MDLs that are performance driven by the labs. EPA only provides some guidance with ranges of MDLs in a method.

(2) Based on your understanding of the issues, are there any types of criteria that you suggest EPA include to evaluate detection and quantitation procedures? If yes, please identify the criterion and provide a rationale for its inclusion.

I do not have any criteria in mind.

(3) What existing detection and quantitation procedures should EPA evaluate or focus on? Procedures from the open scientific literature? Voluntary consensus standards procedures? Procedures from other organizations?

I think EPA should focus on the MDL approach and the detection limit should be performance driven. Each lab should develop their own MDLs and the EPA method should provide some examples and some expectations for each analytes and matrix but let the labs demonstrate their own MDLs. The "market" will then drive the MDLs. If there is a need for more sensitive MDLs then the successful labs will improve their MDLs.

(4) Are the data sets listed in the plan appropriate for use in the detection and quantitation reassessment? Are there other data sets that you recommend EPA evaluate?

I am aware of MDL data sets for the MDLs in method 1638 that could be evaluated.

(5) Is it appropriate to include specific selection criteria in the plan or is it more appropriate to develop selection criteria based on the analysis of issues that will be conducted as part of the plan?

I think the selection criteria should be included so each lab demonstrates their MDLs by analysis of replicate samples of actual field samples , either spiked or unspiked depending on the concentration in the matrix. EPA would provide the guidance in terms of number of replicates.

## **APPENDIX J**

### **Reviewer F Comments**



**Review of:**  
**Plan for the Assessment of Detection and Quantitation Limits Under Section  
304(h) of the Clean Water Act, Dated December 10, 2001**

By:

Reviewer F  
January 28, 2002

Prepared for:

**Versar, Inc.**

1 Introduction

This reviewer has read and reread these documents. The second paragraph of the Charge to Peer Review Panel requests an opinion regarding the validity of the Plan and the likelihood that it will result in an "objective and useful assessment of detection (limit) and quantitation (limit) procedures". None of the five Questions to Peer Reviewers (included in the Charge to Peer Reviewers) address the purpose indicated in the Plan's introduction as the reason the plan was developed, namely, responding to Clause 6 of the settlement agreement. In addition, only the Plan document identifies Method 1631B; the other documents seem to address EPA methods in general. Consequently, I will try to address all the review considerations starting with the Plan.

2 Plan for the Assessment of Detection and Quantitation Limits Under Section 304(h) of the Clean Water Act

The Plan identifies 4 key items associated with satisfying the requirements of Clause 6 of the settlement agreement. These are: Reassessment of EPA's existing MDL and ML procedures; External review of the reassessment; External review of any alternate procedures EPA has under consideration; and Proposal of revised/alternate procedures, if warranted. This is to be accomplished by the end of February 2003. To this end, EPA has established a series of tasks and milestones leading up to the due date. Although not specifically stated, it is presumed that a document will be generated which addresses the four items in Clause 6. Also, because Method 1631B is cited in the Introduction along with Clause 6, it is assumed that the Plan document is intended to address only this method.

EPA has organized this effort into 16 tasks/milestones that are identified in a chart on page 12. The first two tasks have been completed, the resulting output being the documents under review. The organization of the remaining tasks, however, is somewhat confusing. First, there seem to be six first-draft reports, excluding the Federal Register Notice, plus two second-draft reports. I suspect these are sections in the final report document but this is not clear. It appears that the drafts are assembled into a single report as the interim, and only milestone, of Task 9. External Peer Review is then preformed over a three-month period shown as Task 10, starting in May of '02. Final selection of the "Recommend Option" takes place as a milestone (task 9) after External Peer Review is complete.

However, even though the report has been sent out for external peer review, development tasks (Tasks 3, 4 and 7), evaluation tasks (Tasks 5 and 8), and the reassessment task (Task 6), continue to run on through Feb '03. Consequently, it appears that the material developed in these tasks after April '02 will not be subject to external peer review. This appears to be inconsistent with the requirements of Clause 6. Further, why should these tasks continue past the time the Recommended Option has been selected? If the tasks continue does that mean some other Option could replace the one identified in task 11?

In addition, some of the tasks identified in the Plan do not appear to be clearly related to dealing with the four points of Clause 6. The first point of Clause 6 is addressed by Task 6, the second point by Tasks 9 and 10, the third point by Tasks 8, 9 and 10, and the fourth point by Task 7. Tasks 1 and 2 were used to create the documents reviewed her. That leaves Tasks 12 through 16, which appear to be EPA administrative issues that must fit into the time line prior to the completion date. If this is the case, it is difficult to understand how the development, evaluation and reassessment tasks identified above could continue while EPA is writing a Federal Register Notice (Task 12), the Agency is reviewing (Task 13) and OMB is reviewing (Task 14).

At the end of the Introduction to the Plan, there is a statement that the "document contains the detailed plan for the reassessment called for in Clause 6 ...". In fact the Plan contains very little detail. The only thing that comes close to detail is the listing of "issues" that are part of Task 3. There is no description of the processes and/or criteria that will be used in the reassessment. EPA should identify the specific criteria that will be used to select the most appropriate mechanism(s) for determining detection limit(s) and/or quantitation limit(s). If this is not done up front, it may appear that EPA first selected mechanisms, then created justification to support them. This is what Clause 6 seems to be trying to get away from.

Presumably the people involved have the skills and knowledge, and EPA will allow them the time and provide the resources, needed to do the job. Unfortunately there is no way to assess this based on the Plan. EPA identifies a "Core Workgroup consisting of measurement analysts and statisticians within the Office of Science and Technology" but does not provide information on their background or experience. The success of this project will depend on the people involved, so this is critical information.

The Plan indicates that Episode 6000 data will be reviewed. Are these the only data that will be reviewed? Are these data associated with Method 1631B? Are there other data that could be used in addition? If so, will they be used or excluded?

In summary, it is very difficult to see how this Plan will result in EPA being where they want to be when they want to be there. They may succeed, but working to this Plan will not be the reason for their success.

### 3. Charge to Peer Reviewers

The approach described in the Plan does not contain sufficient detail to determine whether or not it is valid. Neither does it contain enough information with respect to how the assessment will be done to determine the likelihood that it will be objective and/or useful. It is also not clear whether the Plan is intended to address only Method 1631B or EPA methods in general. If it is EPA methods in general, the magnitude of the job is much, much greater and it seems unlikely that a valid technical effort could be conducted in the timeframe identified.

4. Response to Specific Questions per the Requested Format

a. General Comments and Impression of Scientific Merit

The Plan is too vague and lacking in technical detail to generate an assessment of its scientific merit.

b. Response to Specific Questions

- (1) Conceptual soundness cannot be evaluated due to insufficient detail. No description is provided on what parameters and/or criteria will be used to assess methods for identifying detection limit or quantitation limit. If one technique/method is to be better than another, what makes it better?
- (2) EPA has not provided a single criterion for performing this evaluation. Without some idea of what they are planning to do, it is not possible to suggest alternatives.
- (3) I believe the charge to EPA is that they look at all existing procedures, see if they can come up with any new ones and then, with some predefined rational, pick the best one. This sounds like a justifiable charge. If the intent of this question is to determine if I have a favorite that I want to be sure is on the list, I do not.
- (4) There is only one data set identified in the Plan, Episode 6000 data. If these are mercury data derived from Method 1631B, they are appropriate for that method. However, because I haven't seen them, I don't know. However, I would be surprised to hear that Episode 6000 data are applicable to all EPA methods. If they are, how was this determined? I know EPA has other data associated detection studies because I've seen EPA statisticians present them at various technical meetings. Also, based on the references identified in the memo to Chuck White from Raphael Kuznetsovski, it would appear that there are a number of other data sets outside EPA. Perhaps the authors would be willing to share them. What I'm not sure of is whether or not the Plan is intended to address other EPA methods.
- (5) It is not just "appropriate" to include specific selection criteria, it is essential if an objective assessment is to be conducted. Otherwise there is the specter that EPA has simply selected criteria that support the conclusion(s) that that they wish to make. This is likely to be obvious to the plaintiffs in the suit against EPA.

c. Specific Comments/Recommended Changes

There are a few typos, judgment is misspelled, and Task 16 on page 10 should identify December 2002, not 2001. It's not the nits that need to be addressed, it's organization and the lack of detail.

d. New Information

None.

e. Additional Reference Materials

None.